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A RELIABILITY ANALYSIS APPROACH TO FATIGUE LIFE VARIABILITY OF AIRCRAFT STRUCTURES

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The Boeing Company

APRIL 1969

TECHNICAL REPORT AFML-TR-69-65

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FORBWORD

The research work reported herein was conducted by The Boeing Company for the Metals and Ceramics Division, Air Force Materials Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, under USAF Contract No. F33615-68-C-1232. This contract was initiated under Project No. 7351, "Metallic Materials," Task No. 735106, "Behavior of Metals," with Mr. R. C. Donat acting as project engineer.

The study was conducted at The Boeing Company's Commercial Airplane Division, Structures Developmental Staff, in Renton, Washington, under the technical supervision of Mr. J. P. Butler, supervisor of the Fail-Safe and Fatigue Group. The period covered by this effort is February 1968 through January 1969, and the report was submitted March 1969.

The research was conducted by Mr. Philip M. Besuner and Mr. Ian C. Whittaker of the Fail-Safe and Fatigue Group of the Commercial Airplane Division. Acknowledgement is due Dr. S. C. Saunders for his many important contributions to the mathematical developments contained within, including all work in Appendix I. A suggestion by Professor A. M. Freudenthal of Columbia University, whose theory and concepts of structural reliability formed the basis for the initiation of this study, led to the adoption of a two-ordered statistic estimator, which subsequently became the backbone of the studies on the dispersion of fatigue life. Professor M. Shinozuka of Columbia University provided valuable aid during the initial stages of the study. Dr. Nancy Mann of Rocketdyne provided timely mathematical consultation vital to the application of a two-ordered statistic and other estimators. Data processing, presentation, and Monte-Carlo simulation by computer would not have been possible without the support of Mrs. Joan Naidu and Mr. T. A. Bray of Boeing's Computing Department. Mr. P. B. Borgwardt and Mr. M. C. McBlroy contributed substantially to the data collection and presentation of results. The majority of the typing of the report was done by Mrs. Carol Daves.

This technical report has been reviewed and is approved.

W. J. TRAPP
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ABSTRACT

The application of reliability analysis methods to the estimation of probable aircraft structural fatigue performance was investigated. Use was made of order statistics to establish the means of assessing the fatigue performance reliability of a fleet or number of fatigue-exposed details. A reliability analysis plan for application to aluminum alloy structural fatigue performance was developed and compared with the current fixed-scatter-factor procedure for determining the safe life of a structural detail. Both the two-parameter Weibull distribution and the log-normal distribution with empirically defined shape parameters were used to make the reliability plan tractable as compared to a distribution-free approach. Maximum-likelihood estimators, including one that considers only the first two-ordered failures, were employed to examine the many variables that might influence fatigue scatter, to qualify fatigue data that represented aluminum structural scatter, and to establish shape parameter values that typified structural fatigue scatter. The sampling distributions of these estimators were required to work the problem and were calculated by means of existing theory or Monte-Carlo simulation. More than 2,000 groups of fatigue performance data were collected, analyzed, and used to demonstrate the feasibility of establishing a shape-parameter value. Based on this estimate, scatter factors have been generated to account for the penalty of limited input information, the degree of desired reliability, and the size of the exposed fleet. Using these factors, the possible effects of the reliability analysis on structural weight, payload, or range were explored for a jet-engined military tanker/transport-type airplane.

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LIST OF ABBREVIATIONS AND SYMBOLS

1. ABBREVIATIONS

E	=	mathematical expectation
exp	=	exponential function
ln	=	natural logarithm
log	=	common logarithm
ML	=	maximum likelihood
MLE	=	maximum likelihood estimator or estimate
P ( )	=	probability of that event described within parentheses
Var	=	mathematical variance

2. SYMBOLS

α	=	Weibull distribution shape or scatter-controlling parameter
β	=	Weibull distribution scale parameter or characteristic life
B_n	=	coefficients, depending on sample size n, used to unbias Weibull shape MLE
b_n	=	coefficients, depending on n, used to unbias Weibull two-ordered-statistic estimates
γ	=	confidence coefficient, showing probability that an estimator takes on values within a given interval
δ	=	a nonnegative number
ε	=	standard normal variate
F	=	when used alone, probability of failure event or, when used with a random variable, a symbol of any time-to-failure distribution function
$\bar{F}_{M;N}$ or $\bar{F}$	=	probability of failure of the component destined to have the M^{th} lowest fatigue life of N independent exposed components
G_i	=	the i^{th} ordered censored test observation, where the test or exposure has been terminated for reasons other than failure
η	=	population average of log failure times, when the population distribution is not necessarily assumed to be log-normal

h = hazard function; also known as the intensity or failure rate function or as the force of mortality

κ = $1/\alpha$, the Weibull parameter that is actually estimated in this report, rather than α itself

k_p = the standardized normal deviate corresponding to some probability number, p. More than one definition has been discovered in the literature; in this report, k_p is defined by

$$\frac{1}{\sqrt{2\pi}} \int_{k_p}^{\infty} \exp\left(-\xi^2/2\right) d\xi = p$$

λ = any unknown parameter

L = likelihood function

μ = log-normal distribution scale parameter or median life

M = order number given to the M^{th} lowest fatigue life in a fleet

N = fleet size; the number of nominally identical, independent structural components exposed to one fatigue environment

n = test sample size

n_f or k = number of failure observations in the test sample

n_s = $n-n_f$, the number of observations not involving failures

Q_n = coefficient, depending on n, proportional to the variance of an estimator's sampling distribution

R = $1-F$; when used alone, R is the single, randomly chosen fleet member's reliability or probability of no failure. When used with a random variable, it is a symbol denoting any reliability function.

$\bar{R}_{M;N}$ or $\bar{R}$ = $1-\bar{F}$, the reliability of the structural component destined to have the M^{th} lowest fatigue life in a fleet of N identically exposed independent components

σ or $\sigma(\log X)$ = log-normal shape parameter

σ^2 = log-normal parameter actually estimated in this report, rather than σ itself

s^2 = sample variance of the logarithm of failure observations only from a test sample

S = total scatter factor ($= S_{n_f} \cdot S_{\bar{R}} \cdot S_{N_{\bar{R}}}$); defined as the ratio of the best estimate of the scale parameter (characteristic life or average log life) to the final (interval) estimate of safe life

S_{n_f} = factor to account for finite size of the full-scale fatigue test sampling

$S_{\bar{R}}$ = factor required to provide a desired level of reliability for a fleet of just one airplane, component, or detail

S_N or $S_{N_{\bar{R}}}$ = factor to account for fleet size exposed; double subscript is used where this factor also depends on the preassigned reliability

S_R = $S_{\bar{R}} \cdot S_{N_{\bar{R}}}$, factor required to provide reliability R to a fleet of size one or, equivalently to provide a lower reliability $\bar{R}$ to all or most of a fleet of size N

T = a discrete random variable denoting the number of failures occurring in an exposed fleet

U = the statistic $\hat{\alpha}/\alpha$ (see definitions of accent marks that follow)

V = the statistic $(\check{\beta}/\beta)^{\hat{\alpha}}$

W = the statistic $(\hat{\beta}/\beta)^{\alpha}$

χ^2 = symbol of the chi-squared distribution

$\chi_\gamma^2(f)$ = the γ-fractile of the chi-squared distribution with f degrees of freedom

X = a continuous time-to-failure random variable usually referring to tests useful in estimating fatigue scatter only

X_L = log X

Y = a time-to-failure variable usually referring to the fatigue performance of one structure or structural component in service or to fatigue results from full-scale tests useful in estimating mean life

$Z_{M;N}$ or Z = a time-to-failure random variable denoting the M^{th} lowest fatigue life in a fleet service exposure of size N

$Z_{\bar{R}}$ or Y_R = safe life, $Z_{\bar{R}}$ represents the $(1-\bar{R})$ fractile of the distribution of Z; Y_R represents the (1-R) fractile of the distribution of Y. ("Life" is defined as the time to initial appearance of fatigue cracking at a detail or in a structure.)

NOTE: The standard practice of using uppercase letters to denote random variables and corresponding lowercase letters to denote numerical values the variables may take is followed, in most instances, in this report.

3. ACCENT MARKS DENOTING ESTIMATION

(a) Bar, as in $\bar{X}_L$ or $\bar{n}$, may denote an average or any sort of point estimator. It is to be noted that the bars in $\bar{F}$ and $\bar{R}$ do not have this meaning (see Par. 2, "Symbols," above).

(b) Boat, as in $\breve{Y}_R$, denotes a one-sided bound of a confidence interval estimate. This accent mark may be replaced by or used in conjunction with the subscript γ as in $\hat{\beta}_\gamma$ or $\breve{\beta}_\gamma$.

(c) Hat, as in $\hat{\sigma}$, symbolizes the maximum-likelihood point estimate

(d) Double hat, as in $\hat{\hat{\sigma}}$ represents an estimator (usually the MLE) that is free or has been freed of bias.

(e) Prime, as in $\tilde{\kappa}'$, denotes an estimator taken from more than one sample.

(f) Squiggle, as in $\tilde{\kappa}$, stands for an unbiased two-ordered-statistic estimator of a shape parameter.

(g) Vee, as in $\check{\beta}$, denotes a scale-parameter MLE that must depend on an estimated value rather than on a true shape-parameter value.

SECTION I

INTRODUCTION

The structural reliability of an airplane is dependent on the likelihood of a fatigue failure or a static failure, or a combination of both. At the present stage in the evaluation of the aluminum alloy airframe the expectancy of fatigue crack initiation can be of a higher order than that of a static failure. On the other hand, it should be realized that with a well-designed, fail-safe structure, subjected to regular and correctly scheduled inspections, the fatigue damage initiation incident should not progress beyond the detectable crack stage to the level where a structural failure is imminent. The aircraft designer still has a real requirement to assess the expected time at which cracks may initiate on a particular structure, in order to insure a sufficiency of trouble-free performance. This report is primarily concerned with the development of a reliability analysis method for application to this fatigue problem as affected by safety or maintenance requirements.

Some clarification of the term "reliability analysis" is necessary as its application to structures is not the usual one of component reliability leading directly to the system's reliability or to total reliability through an accounting of the interdependence of components, fault-tree analyses, or other such procedures. Structural reliability as envisaged here is concerned with a specific structural detail and is heavily dependent on the testing of full-scale structural details or primary structural components. For example, Raithby (1) has shown that this form of testing is essential to obtain an estimate of available fatigue performance that bears any resemblance to that actually achieved. It has also been observed that structural fatigue problems are frequently initiated by fretting, a process that is not reproduced in the well-designed simple laboratory specimen and its test program. Likewise, estimates of the mean performance based on such simple tests would probably be larger than that demonstrated by a structure in service. The significant goal of a reliability analysis is to determine the probable time to the initial appearances of fatigue damage in structures or details, a task even more obviously beyond the scope of the simple specimen.

Other real hazards--beyond those of the test specimen--confront the designer. Load environment, physical environment, and actual local stress response of a detail to its loading environment all lend a confounding element to the task. Gross misrepresentation of airplane fatigue performance through inadequate fatigue test design and interpretation will generally lead to poor reliability estimates. However, it is as meaningless to associate these errors with the reliability analysis as it would be to regard the errors in the assumed functional form of the fatigue life distribution as weaknesses in the structural analyses.

Current analytical practice (Ref. 2) for military aircraft for insuring an adequate or safe level of fatigue performance by aircraft structures does contain some of the characteristics of a reliability plan. Namely, a structural detail, component, or complete airframe is fatigue-tested to a defined and representative loading environment. Additionally, a goal is selected at some multiple of the defined and expected service life of the structure. The applied safety factor is usually selected quite arbitrarily either on the basis of judgment or with guidance from some possible consideration of confidence and probability levels of statistical analysis.

In past assessments of fatigue scatter, the log-normal distribution has often been used. Attention has also been given to the Weibull-type distribution for defining fatigue variability and predicting potential fatigue performance. The important consideration is that a level of fatigue performance, statistically defined or otherwise considered acceptable, is set for the structural detail. A vital part in this assessment has been the use of mean or median fatigue performance for the detail. However, these past analyses have not considered the likely appearance of early or first fatigue damage during the exposure of a quantity of details to the fatigue environment. The expected time to first failure, rather than either a probable level or the average performance with its implied high number of failures (about half of the fleet, prior to the design goal), has been proposed by Freudenthal (3) as an important design parameter for structural reliability. The early failure is also a serious economic consideration that could possibly influence future decisions; consequently, this added factor must be investigated and carefully weighed by the design engineer. It is known that if fatigue life comes from a population whose probability density is of a specified limited type, the extreme values (initial failures) of an indefinitely large sample will have a Weibull distribution. For the problem of the airplane fleet, where a substantial number of structural details are involved, the use of this asymptotic form seems appropriate. Some recent papers describing or using this approach are available in the literature (4 through 9), and this report is an extension or development of this work, with special emphasis on the estimation procedure part of the problem.

Section II presents a complete outline of the proposed reliability analysis and makes comparisons with the existing procedure for determining the safe life of an aircraft structure. The plan has been divided into five steps. The first four steps describe the assumptions, estimating procedure, and the influence of sample size. The final step defines the influence of fleet or number of detail exposed to the fatigue environment.

Section III contains discussions on the processing techniques used on the mass of collected data, the procedures developed for coping with problems that arose during processing, and the results that were obtained from the evaluated fatigue performance data. A dissertation is presented on a revised scatter-factor approach for calculating the safe life, as defined in Sec. II, of an aluminum structure. The possible performance penalties suffered by adoption of this proposed method are also discussed.

Section IV presents an outline of the analytical groundwork needed for estimating the distribution shape parameters from the mass of collected fatigue data. The techniques for obtaining bias and variance values, the method of weighting estimates from groups of varying sample size, and the procedure for obtaining interval estimates are presented.

Section V summarizes all the additional formulations that were used for estimating a safe life for an aircraft structure, which include the techniques for calculating the scale parameters and the so-called scatter factors.

Section VI presents a list of the conclusions made, together with a few suggested recommendations.

Appendix I contains proofs for the important theorems used in the analysis, and some aspects of the Monte-Carlo techniques that were adopted are discussed.

Appendix II lists all the source references and tabulates the salient features, including the point estimates of the shape and scale parameters, of the collected fatigue performance data.

Finally, Appendix III lists the cyclic life for every individual specimen assessed in this report.

SECTION II

OUTLINE OF THE RELIABILITY ANALYSIS

The basic objective of this investigation is the application of reliability analysis to aircraft structural fatigue performance, in terms of the first- and second-ordered times-to-fatigue-damage initiation. Statistical definition of fatigue variability is essential to the achievement of this objective.

The generality, definition, and input data requirements of distribution-free methods may make their application impractical and economically forbidding. Furthermore, rationale just seems to point toward a more tractable definition of fatigue variability by some reasonable and determinable distribution. The two-parameter log-normal distribution, by virtue of its easy transformation from the well-known normal or Gaussian distribution, has been a useful engineering tool for evaluating reliability in fatigue performance. The two-parameter Weibull distribution function has also found an application to fatigue variability studies. Presuming knowledge of the shape parameters of these distributions, statistical analysis procedures that account for sample size are readily developed. Using these procedures, the analyst can calculate interval estimates of the true fatigue life distribution at any desired level of confidence. The additional tolerance for probability of failure of any one detail is then also definable. Order statistics carry the fatigue reliability analysis a step forward by focusing on the likelihood of the first or the second failure in an exposed fleet or in groups of details. In any case, development of a reliability analysis as either a probable level of fatigue performance or, even more detailed, in terms of an ordered statistic has considerable complication over the simple exercise of applying a scatter factor to an estimated average or median fatigue performance.

The main effort of this research project has been devoted to the development of the reliability analysis tools that can be applied to the aircraft structural fatigue performance task. Attempts have been made to fully utilize all applicable fatigue data and to employ only mathematically precise estimation procedures in the analysis and detection of important variables and vagaries of structural fatigue performance.

The analysis does <u>not</u> account for all unknown or inadvertent systematic errors that may cause the full-scale fatigue test result and/or the ensuing life calculations to grossly misrepresent the actual aircraft fatigue performance. Such errors could arise from the assumed load environment, customer usage, and cumulative damage theory as well as from the specimen design and fatigue test setup. In all that follows, it is assumed that the life estimate arising from full-scale tests is drawn from the same statistical population as are the corresponding aircraft's structural lives and that this population distribution

represents fatigue <u>strength</u> variability only. In analyzing strength variability, specific attention has been given to accounting for the sample size of full-scale developmental fatigue tests and for the eventual size of the fleet to be exposed to a defined fatigue environment. This has been done through the application of statistical inference theory and of order statistics concepts respectively.

The need for this accounting is clear when the current approach to create reliability, represented by Fig. 1, is compared to the proposed, more comprehensive approach outlined and described schematically in Fig. 2.

In the current approach, the symbol $\bar{Y}$ in Fig. 1 is a measure of the average performance of developmental fatigue test specimens and is usually taken to be the mean of log times or cycles to failure. This average performance is then divided by a so-called scatter factor, whose value may range from two to four, to obtain Y_S, which is traditionally known as the "safe life," a life at which the probability of the initial appearance of fatigue cracking at a detail is sufficiently low. These values of the scatter factor have been subject to interpretation. Hopefully, these factors would provide an estimate of the service life prior to initiation of fatigue cracking. In other circumstances, they are credited with providing a fatigue performance with reasonable maintenance throughout the economical life of the structure. Fail-safe design concepts--with their damage containment capability--have considered that the magnitude of the factor can be reduced over that required for non-fail-safe structure. Seemingly, the scatter-factor value chosen is independent of the number of details to be exposed in service and of the sample size of the full-scale airplane test(s).

In contrast, the difference between mean test performance and subsequently calculated probable or safe life is, in the proposed approach, strongly dependent on sample and fleet size. Recognition of the relative importance of the structural detail, including the degree of redundancy, may still be accomplished using the plan outlined in Fig. 2. However, in this new approach, an acceptable level of reliability must be specified. Scatter factor may then be calculated; to specify scatter factor a priori is equivalent to specifying a reliability that is almost certainly not of the desired level.

As the first of five major steps in applying statistical techniques it was decided to consider the untruncated two-parameter Weibull distribution as a random time-to-failure model because of certain desirable mathematical properties it possesses (these are discussed in Sec. III). That is, the fatigue life Y is assumed to be a random variable with distribution given by

$$F(y) = 1-\exp\ [-(y/\beta)^{\alpha}] \text{ for unknown } \alpha,\beta > 0 \qquad \text{(II-1)}$$

The traditionally cited log-normal model was also applied to the problem in a less complete manner due to difficulties in working with estimates of its two parameters from incomplete or censored samples.

These are samples in which the testing of one or more specimens is regarded as being terminated for reasons other than failure.

At this time, no attempt has been made to test the validity of any one distribution or even to reject one model for another. However, somewhat different conclusions may be reached from applying different distribution functions to the same data. Of course, the necessity to generate very large samples of controlled fatigue data may preclude adequate resolution of this problem. To emphasize the need for making realistic assumptions about the distribution of fatigue lives, the Tchebycheff inequality will also be applied to the problem to indicate a possible conclusion when no assumption is made about the functional form of the true time-to-failure distribution.

Given reasonable accuracy in the chosen model, the second step is the most important, necessary, and critical step in the analysis. It was assumed that, for a wide variety of structure and structural simulation configurations and types of loading, the variability or dispersion of the logarithms of times-to-failure is nearly constant. More specifically, with reference to the distribution function itself, the assumption is that the scatter-controlling or shape parameter of the assumed Weibull (or log-normal) model has a unique value for this same set of conditions. This unknown value of the Weibull shape α has been estimated from a collection of more than a thousand applicable samples of two or more fatigue specimens each, and the errors in the uniqueness assumptions are considered to be small enough for practical application. A large proportion of the later sections of this report is devoted to discussing and justifying this important conclusion.

With the shape parameter α accurately estimated and subsequently regarded as being fixed, we need only obtain from full-scale testing an accurate estimate, $\hat{\beta}$, of the scale parameter β to complete the third stage of the plan. This step establishes Curve A in Fig. 2 and produces the best point estimate possible of the complete distribution of fatigue lives. It is from this curve, with equation

$$\hat{F}(y) = 1\text{-exp}\,[-(y/\hat{\beta})^{\alpha}] \tag{II-2}$$

that the most likely probability of failure at a given fatigue life is estimated.

It is standard procedure in any engineering discipline to specify allowables as values somewhat less than the most likely estimates. One sensible way to do this was chosen as step four, where a confidence interval estimate $\check{\beta}_{\gamma}$ of β is made that accounts for the finite size of the full-scale fatigue sampling so that

$$P(\check{\beta}_{\gamma} > \beta) = \gamma \tag{II-3}$$

The confidence coefficient γ is generally specified at some acceptable level. The estimate $\hat{\beta}_\gamma$ along with the "known" shape parameter α completely determines Curve B, a plot of the interval estimate of the complete distribution, with equation

$$\hat{F}_\gamma(y) = 1 - \exp\,[-(y/\hat{\beta}_\gamma)^\alpha] \tag{II-4}$$

It follows immediately from Eqs. (II-3) and (II-4) that

$$P\,[\hat{F}_\gamma(y) \geq F(y)] = \gamma \tag{II-5}$$

In other words, with probability γ, the estimated failure probability (reliability) from Eq. (II-4) will be greater than (less than) the unknown true failure probability (reliability).

As a structural design specification, the type of confidence statement given above is certainly not without precedent. For example, the "A" and "B" values of ultimate strength of structural alloys quoted in MIL-HDBK-5A (Ref. 10) are based on a confidence interval estimate analysis that differs from the aforementioned one in only two respects. The first difference is that the random variable ultimate static strength was assumed to have a two-parameter normal distribution. The second difference, one of greater practical importance, is that both parameters were assumed to be unknown in Ref. 10 and were estimated from one large sampling, of at least 100 observations, of tensile specimens. As outlined before, the shape parameter was, in this study, assumed to be common to the actual aircraft as well as to the large collection of data from which it was estimated. Some assumption regarding prior information about the degree of fatigue scatter, as measured by the shape-parameter estimates, is obviously required in this study because the full-scale fatigue test sample size typically does not exceed one or two observations. Two parameters cannot, of course, be estimated at all from a sample of one and cannot be estimated accurately from a sample of two observations.

The first four stages of the reliability plan have led to Curve B, which is simply a statement, at some confidence level, of the reliability of an aircraft or aircraft structural detail (depending on the nature of the full-scale test), chosen randomly from a universe of nominally identical counterparts, as a function of time of exposure to the loading environment. If the reliability R of an arbitrary fleet member is judged to be a suitable measure of safety or of freedom from repair, the plan terminates upon administrative specification of an acceptable value of R and upon reference to Curve B to certify a corresponding "safe life."

In many or possibly in most instances, the arbitrary specification of an acceptable value of R is not a sufficient basis for certifying safe life for a number of details or a fleet of airplanes. With regard to the safe or repair-free operation of a fleet, both customer and

vendor usually expect that the entire or nearly the entire fleet demonstrate acceptable reliability. Precise definition is one step toward this goal.

With reference to the proverbial chain that is no stronger than its weakest link, it is only a matter of definition to equate the reliability of the majority of the fleet with the reliability of one of the weakest of its (assumed) independent nominally identical members. That is, the reliability of the entire fleet is not different from the reliability of its weakest member. In general, the reliability of the vast majority of the fleet, considered as a package and excluding only the weakest M-1 members, is defined as the reliability of the M^{th} weakest fleet member.

The random variable $Z_{M;N}$, used to denote the fatigue life of the detail destined to have the M^{th} lowest of N fatigue lives, is an example of an order statistic. It has its own statistical distribution. This distribution is completely determined by the randomly chosen member's fatigue life distribution. Note that the two distributions are never equal except in the trivial case of $M = N = 1$.

Fortunately, the precise calculation of the order statistic's distribution from any assumed, estimated, or known parent distribution function is a simple matter whenever the trials are independent, however complex the parent function. The derivation of the cumulative binomial distribution, which may always be used to map the parent into the order statistic's distribution, is given in many standard statistical texts (e.g. Ref. 11). In Fig. 3 this summed binomial formula is plotted for several combinations of M and N. The resultant curves are worth examination by all readers, but they will be especially enlightening to those not familiar with the behavior of order statistics, since they point out significant trends that are perhaps not obvious. The most striking examples arise from the way the curve slopes increase with M, leading to such surprising facts as:

1) Greater fleet member reliability R and therefore larger scatter factors and more weight on the airplane results from a specified reliability of 99% for the weakest of 10 than from the same specification for the second weakest of 100. The reverse is true for lesser reliabilities such as $\bar{R} = 0.90$.
2) In a similar vein, if the reliability of the single, randomly chosen fleet member is greater than 0.97, it is more likely to experience one or more failures in a fleet of size 4 than it is to experience two or more failures in a fleet of 20. For $R < 0.97$, this trend is reversed.

This trend, which depends vitally on the independence of fleet members but which in no way depends on the assumed failure distribution could be interpreted by the engineer or administrator in a practical manner. It points out the fact that, except for cracks or failures that are "intolerable," it would be quite worthwhile to be able to specify reliability for the second or third weakest fleet member rather than to specify a similar reliability level for the weakest fleet member.

Returning to the final stage of the reliability plan as outlined in Fig. 2, it is proposed that an acceptable reliability level $R_{M;N}$ be specified from which the cumulative binomial distribution can be used to calculate the corresponding "general" reliability $\bar{R}$. The certifiable safe life may then be found from Curve B to complete the exercise.

In summary, the object of the overall statistical analysis is to obtain an accurate and reliable estimate $\check{Z}_{\bar{R}}$ of the "true" design life $Z_{\bar{R}}$, where $Z_{\bar{R}}$ satisfies the probabilistic statement:

> The proportion of the failure times Z that will exceed life $Z_{\bar{R}}$ is equal to $\bar{R}$, where Z denotes the M^{th} failure time in each fleet of a universe of fleets of size N.

In equation form this is expressed as

$$P(Z \geq Z_{\bar{R}}) = \bar{R} \tag{II-6}$$

Since $Z_{\bar{R}}$ can only be estimated from sample data we can, at best, obtain an estimate $\check{Z}_{\bar{R}}$, which is conservative with confidence γ, such that

$$P(\check{Z}_{\bar{R}} \leq Z_{\bar{R}}) = \gamma \tag{II-7}$$

Specification of levels of reliability and confidence, the fatigue test sample size, and the fleet exposure must remain a joint managerial effort between customer and vendor. It is recognized that, as a practical matter, these specifications will depend partly on their resulting calculated scatter factors and ultimately on structural weight. The relationship of structural weight and level of reliability is explored in Sec. III.

SECTION III

DISCUSSION

1. DATA EVALUATION PROCEDURES

a. General Procedure

The choice of the Weibull statistical model can be justified on the basis that it belongs to the class of asymptotic distributions of the extreme (smallest) values and may adequately reflect the distribution of the proposed design parameter, namely, the time to first failure in complicated, multicomponent, fatigue-critical structures. Moreover, the Weibull distribution does reflect an increasing hazard rate that does seem to be a logical argument for the fatigue process. The two parameters composing the statistical model represent fatigue variability, shape parameter α, and the fatigue performance of the structural detail--the scale parameter β. It was decided that with the assumption that both parameters are unknown, computed analyses would be overly conservative and a more acceptable solution could result if some value for one of the parameters was established. The scale parameter was known to be influenced by all the variables of material, geometry, loads, environment, etc.--and therefore was obviously not the appropriate parameter for this exploratory task. Consequently, effort was concentrated on establishing the behavior of the shape parameter under actual fatigue conditions. Unfortunately, available fatigue data have been almost entirely obtained from tests with groups of limited size, usually involving from two to five specimens. The results of these tests taken on their own merits are worthless for assessing the typical parameter of the parent population, but it was assumed that the evaluation of a large mass of data obtained from numerous fatigue tests would demonstrate the possibility of establishing the shape parameter. This task was of sufficient magnitude that it was decided to limit the study to only the aluminum alloys and to test the feasibility of a reliability approach on aluminum aircraft structures.

A comprehensive literature search of the available aluminum fatigue performance data was conducted, and more than 2,000 groups of data representing approximately 11,000 specimens were summarized and analyzed. It should be noted that not all the groups were independent of each other since, on a minority of occasions, a few smaller groups were pooled to form larger groups to facilitate evaluation of certain specified variables within the data sample. More data were collected during the literature search than were actually analyzed; some obvious trends observed during the reduction of the previously mentioned groups of data rendered unnecessary an analysis of all the data collected. These observed trends concerned data from rotating bending tests, data on hand forgings, and data from tests on unnotched specimens. The first two types of data both demonstrated considerably greater scatter than was noted for typical aircraft structures, whereas the third type showed notably lower scatter. Similar trends can be observed by examining the tabulated results presented in Ref. 12.

b. Analytical Procedure

The analytical technique adopted for estimating the Weibull shape parameter α involved the numerical solution for the maximum likelihood estimate (MLE), which was considered to provide either the best[1] estimate or nearly so for this test and indeed for most other applications. The estimating equations for both complete and censored samples given in Ref. 13 are not explicit and had to be solved numerically by the Newton iterative procedure, which required the use of a computer.

A comprehensive computer program was generated that encompasses some of the many variables contained in the test data. For example, the variables of differing materials, geometries, loading conditions, laboratory types versus full-scale specimens, etc., have been identified, and the computer output has been arranged to provide this information. A breakdown of the 11-digit description code used in the program is given in Appendix II. The initial values generated for each data group were point estimates of the shape parameter $\hat{\alpha}$ obtained from the unbiased maximum likelihood estimates of κ, where $\alpha = 1/\kappa$, and the unbiased MLE of the scale parameter or characteristic life $\hat{\beta}$. The value of characteristic life has been included to complete the description of the data only and has not been used for any ensuing analyses.

A study of these point estimates of the shape parameter showed that several data resulted in very small values of α, signifying high scatter. A closer scrutiny revealed a consistent trend in these data, namely, the existence of stronger specimens with correspondingly higher cycles-to-failure within what may be called a typical sampling of fatigue data. The results studied would suggest that these high values occur within the upper 10% band of the failure times of a fatigue sample. The Weibull model cannot accept the existence of high-time outliers and when operating on data containing this phenomenon attempts to account for them by first overcompensating and then indicating very low time failures. To illustrate this point a few <u>simulated</u> groups of data were analyzed and the results given in Table I.

An examination of examples 1 and 2 from Table I shows that the bulk of the data was kept constant but that, in the first case, one specimen had a life an order of magnitude above the average, whereas the second example had an early failure an order below the average. It was noteable that example 1 with the high-time outlier showed extremely high scatter with correspondingly low cyclic values at the 10% or less failure probabilities, but example 2 with the low-time failure was treated as moderately high scatter, with computed probabilities of failure that were more consistent with the data.

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[1] The word "best", as used here, has a mathematical definition. An estimator is best if it possesses minimum variance among all estimators. It can be shown that the MLE is the best asymptotically normal estimate.

This problem does not disqualify the Weibull distribution as untypical of fatigue data; it merely suggests that the minority of data, containing specimens that were much stronger than the average, should be censored to exclude these specimens, which obviously come from a different population, that is, have a different scale parameter β. This process is by no means unprecedented, as Weibull himself has observed (14 and 15): "Some of the specimens may endure a number of stress cycles much larger than estimated from the distribution function" and "There is no sense trying to fit a single function, normal or not, to the complete distribution. For this reason, the data have been censored, choosing a point of truncation well below the 'knee' (p = 90%)."

It should be reemphasised that the best estimate comes from a consideration of all the results in a data set except for those groups containing specimens from mixed populations when it would be erroneous to fit all the data to one distribution.

As a result of the previous arguments a criterion was established in the MLE computer program such that whenever high-time outliers were involved, a reiterative estimation procedure was conducted to remove their influence on the shape parameter. The technique that was developed is best described by referring to the examples given in Table II. The three groups of simulated data presented are identical, except that the second group contains two additional high-time outliers that are an order of magnitude above the majority of the data, and the third group with two low-time failures an order of magnitude below the average of the remaining results. In example 1, the estimate of the reciprocal shape parameter fell within the acceptable range of $\hat{\varepsilon} < 0.50$ and so no censoring was attempted. However, both examples 2 and 3 contained data that resulted in estimates of the reciprocal shape parameter that were above the arbitrary threshold and that consequently initiated the censoring procedure. It was noted that in example 2 the rejection of the first high-time outlier did not cause much fluctuation in the estimate of ε, but with rejection of the second outlier a dramatic change in $\hat{\varepsilon}$ was effected. (See second and third estimate, where the ratio of second estimate/third estimate > 1.50). Further censoring of the data verified this estimate of the reciprocal shape parameter as stable and therefore acceptable. In example 3, censoring was again attempted because of the high scatter indicated by the initial estimate. However, this scatter was the result of the two low-time failures and the censoring of any longer lived specimens could not improve on the initial estimate, which consequently remained unchanged. In summary, this heuristic procedure was used to calculate maximum-likelihood-point estimates of the data shape parameters, where--for the large majority of the groups--all the results were utilised in the analysis, but for the remaining minority of groups some censoring of the data was necessary to obtain reliable estimates.

An additional, more theoretically acceptable estimation procedure, which also circumvented the problem of the high-time outlier, has been investigated and a program developed around this estimator. The ensuing analysis estimates the Weibull shape parameter after considering

only the first- and second-ordered failures from any group of data of any size n. The argument for this estimator was, as before, the great interest of the airplane designer regarding the expected minimum fatigue performance of a structure. Furthermore, it was known that the extremal values of a population tended toward the Weibull distribution in behavior, and the examination of the initial failures using this statistical model appeared justified. This report has used the unique, linear, unbiased invariant estimator of the Weibull shape parameter for the two-ordered-failure estimation procedure, namely, a derivative of the maximum-likelihood estimator of κ $(\equiv 1/a)$, from consideration of the first and second of n total failures [Mann (16)].

One further problem, namely, how to evaluate the estimates of the shape parameters resulting from the analyses of the mass of collected fatigue data, was investigated. It must be remembered that the vast majority of the data came from a multiplicity of test groups of small sample size that were of limited use individually but that collectively were of sufficient mass to substantiate the premise that their average value would converge on the true value. The problem of weighting estimates from groups of differing sample size was examined in two separate ways. It had been noted that groups of a sample size of two, three, four, and five specimens appeared to be sufficiently numerous that a separate treatment of each sample size was feasible and consequently it was attempted. It was later observed that in Mann's recent paper (17) a procedure for weighting unbiased estimates from groups of differing size had been used; this procedure was therefore incorporated into the investigation, thereby providing the means for generating an unbiased estimate of the weighted average value of the shape parameter for the mass of fatigue performance data. Unfortunately, it was not possible to weight in the minority of data of small sample size that had been censored either during testing or by the high-time-outlier censoring process described earlier. This comment applies only to the MLE procedure and results because two requisites of the weighting process, namely, a knowledge of the bias and variance values for censored data, were unknown. Monte-Carlo methods had been used to generate some of the desired values, but further results are necessary to establish a comprehensive listing that can then be incorporated into the weighting procedure. This limitation is of no real consequence, however, because only a few groups of data were affected and unaccounted for. Exceptions to this limitation occurred whenever the groups of censored data were sufficiently large that asymptotic theory could obviously be applied.

More detailed descriptions of the analytical techniques mentioned in the preceding paragraphs are given in Sec. IV.

2. RESULTS OF THEORETICAL STUDIES ON POPULATION PARAMETERS

An examination of the maximum-likelihood estimating equations of complete or certain censored data revealed that the following quantities were parameter-free, that is, independent of the parent population parameters (refer to Appendix I):

$$U = \hat{\alpha}/\alpha$$
$$V = (\hat{\beta}/\beta)^{\hat{\alpha}}$$
$$W = (\tilde{\beta}/\beta)^{\alpha}$$

The unknown population parameters α and β are the true Weibull shape and scale values respectively, whereas $\hat{\alpha}$, $\hat{\beta}$, and $\tilde{\beta}$ are the corresponding MLE, with $\tilde{\beta}$ the value when α is known and $\hat{\beta}$ when α is unknown.

Because the distribution of the statistic W is known exactly from theory, but those of U and V were unknown, computer simulation techniques were used in conjunction with MLE procedures to obtain empirical distributions for the unknown quantities mentioned above. Some numerical results are given in Tables III, IV, and V; these results were plotted on normal probability paper (Figs. 4, 5, and 6) to indicate, graphically, the deviation of the important statistics 1/U, V, and W, from the "perfect" value unity for various groups of data of finite sample size.

Figure 4 shows the reciprocal transformation of the empiric distribution of $\hat{\alpha}/\alpha$. This reciprocal of U was considered because it had received recent attention in the literature (18). The distribution 1/U for the sample size n = 2 was also known exactly from theory and has been included to demonstrate the "goodness" of the simulation results obtained in this study.

Figure 5 shows the empirical distribution of the MLE of the Weibull scale parameter β, without the benefit of any prior knowledge regarding the shape parameter α. It is obvious that under this restriction a designer, given the results of a test on five or fewer specimens, must make an unfortunate choice between low confidence in average or characteristic life prediction or excess weight. Figure 6 shows, however, that given a prior knowledge of the exact value of α, samples of only one may be adequate for obtaining both high confidence levels and reasonable weight simultaneously. Some stage between these extremes of no knowledge and complete knowledge of the shape parameter would be representative of reality.

Tables III and IV include results to provide some insight into high-time, single-stage, type-II censoring. Type II censoring involves the cessation of testing after the occurrence of a predetermined number of failures, whereas type I censoring refers to that form of testing in which the maximum number of load applications is predetermined and thus results in the cessation of testing either by specimen failure or by the expiration of the preset time period. Single-stage, type II censoring was of paramount interest not only because it typified the majority of the censored data groups but also because it was the model for the

two-ordered-failure estimation procedure used in this report. Appendix I establishes that under this form of censoring $1/U$, V, and W are parameter-free.

Tables III and IV give the empirical distributions of $1/U$ and V for two examples, namely, the complete case of three failures from a sample of three, and the censored case of three failures from a sample of five specimens. It can be seen that the scale parameter β is more accurately estimated from the censored case of the three weakest in five, but the shape parameter α is estimated equally well from the smaller, complete sample. Now consider the example when all five failure times, in the sample of five, were known, rather than only the three weakest in five. The tables show that the estimation of α is improved by the increased knowledge, but that the estimate of β is improved only slightly. These limited examples do reflect some important trends, such as the improvement in estimation of scatter, or α, gained by the knowledge of both low and high times to failure rather than just one of the extremes. Furthermore, it seems that the third failure in a sample of five is a better indicator of central tendency, or of β, than, for example, is the second failure in a sample of three.

Figure 7 is a joint presentation of computational results obtained during this study and of results given in a recent paper (18). Sampling error in the maximum-likelihood estimate of α was measured by the plot of the variance and of the expected loss of $1/U$ (i.e. $\alpha/\hat{\alpha}$) versus sample size (complete samples). Some additional (rectangular) points were located on this plot and give the expected loss of $\alpha/\overline{\alpha}$. The latter estimate, called the simplified method of moments, is obviously more easily obtained than $\hat{\alpha}$, but is also, as shown in Fig. 7, less accurate. In fact, Ref. 18, which reviews all estimating procedures for the Weibull parameters, obtained results showing that in most cases the maximum-likelihood estimates had the least expected loss and hence the most accuracy of all reviewed estimators.

3. RESULTS OF DATA ANALYSES

a. General Observations

Appendix II itemizes the individual characteristics of each of the collected data groups. Data for 2,000 groups representing 11,000 specimens are listed and include fatigue performance data on the well-known aluminum alloys of 2024, 7075, and 7178, together with some of the lesser used alloys such as 2014 and a variety of the European alloys like DTD687A, DTD610B, etc. Specimens formed from sheet, plate, bar, extrusion, and forging are represented in several configurations ranging from the simple unnotched and notched types to structural simulators—such as mechanically fastened, or bonded, or spot-welded joints—to structural components and full-scale structures. Testing conditions encompassed axial loading, both tensile and compressive; flexural and rotating bending; both constant-amplitude and variable-amplitude testing techniques; and ranged from low cycle (below 10^2 cycles) through to high cycle (above 10^6 cycles) fatigue performance testing. It is also notable that the great majority of the data comes from groups of a sample

size of two to five specimens and that only a small minority of groups contain 20 or more specimens.

A study of the resultant point estimates of the shape parameter given in Appendix II revealed some obvious trends. These concerned the large scatter demonstrated by rotating bending tests and by fatigue data on hand forgings, with both groups responsible for some of the largest scatter values recorded (e.g. $\hat{\alpha} < 0.5$). It was also noted that several tests on axially loaded, edge-notched specimens demonstrated consistently lower scatter than normal. Further investigation revealed that the specimens used in these tests had been manufactured with exceptional care from a controlled stock of material so as to minimise the effects of fatigue scatter on the ensuing tests (Refs. 19, 20, and 21).

The obvious trends just mentioned demonstrated the existence of some data within the collected mass of fatigue results that could be disqualified as untypical of the dispersion expected from aluminum airplane structures. It also suggested the advisability of a closer scrutiny of all the data, which was subsequently undertaken.

b. Factors Influencing Fatigue Scatter

The two-order-statistic estimator in conjunction with a weighting technique, which are both explained in Sec. IV, was used to examine several of the known variables within the fatigue performance data. The results of the analyses have been tabulated in Table VI and plotted in Figs. 8 through 14, which reveal several interesting aspects of the fatigue performance of aluminum. It is apparent from Table VI that the itemized variables are not wholly independent, as any one test result may be included in several of the listed categories. Nevertheless, the comparisons made are justified and demonstrate that with few exceptions fatigue data come from a parent population having a Weibull shape parameter in the range $4 < \alpha < 5$.

The initial run consisted of all the gathered data, which contained data that had very high scatter (e.g. hand forgings, unnotched rotating bending, etc.) and other data with very low scatter from carefully controlled tests. The opposite trends of these data tended to be self-canceling, and the resultant weighted average estimate of κ (i.e. $\hat{\alpha}'$) was a fairly acceptable value. The next result summarized only that data suspected of being at some disagreement with the general trends, that is, the items just enumerated. These results were plotted in Fig. 8 and describe the greater scatter that was expected. The third result, represented in Table VI and plotted in Fig. 9, shows the effect of isolating only that data found to typify the fatigue scatter experienced by aircraft structural components. These data included results from:

1) All the investigated aluminum alloys
2) All the notched configurations, ranging from the simple monolithic notched specimen to the full-scale structural component
3) Both axially loaded and flexurally loaded tests
4) Both constant- and variable-amplitude tests
5) The fatigue performance range of 10^2 to 10^6 cycles

It is obvious that the criteria listed above cover a broad range of data, and the subsequent results and figures are presented to substantiate this conclusion. Before proceeding, however, it should be noted that with the rejection of specific data that had demonstrated untypically large scatter (e.g. notched rotating bending tests, results from hand forgings, low-amplitude/high-life fatigue data, compression-compression test results, and data on bonded joints, together with data showing untypically low scatter [e.g. fatigue tests on unnotched specimens and also one particular set of notched data that had been extremely carefully machined to specifically minimize scatter]), the weighted average estimate of κ is reduced from $\hat{\kappa}' = 0.26$ for all data to $\hat{\kappa}' = 0.22$ for the specified data.

Figure 10 compares the cumulative frequencies of the three aluminum alloys: 2024, 7075, and 7178. Only those data meeting the specified criteria (listed in the preceding paragraph) have been analyzed, and it can be seen that there are no obvious differences in the distributions of these materials. The 7178 curve shows some deviation over part of the range, but it should be noted that the sample size was comparatively limited. Figure 11 compares the differing specimen configurations of simple monolithic notched small structural simulators, such as lap joints, and the full-scale structures and structural components. Again no real differences were noted between the various geometries, and a comparison with the data in Fig. 10 showed that the cumulative frequency plots were similar for the differing variables of material and geometry. Figure 12 compares the results of constant-amplitude and variable-amplitude testing techniques, and it can be seen that variable-amplitude testing does show slightly lower scatter. It should be noted that the sample of variable-amplitude data contained considerably fewer groups than the constant-amplitude data, but this alone might not account for all the difference. A closer study of the variable-amplitude data revealed that one set of results obtained from Ref. 22, showed behavior different from the observed trend. It had been noted during the course of this study that the ratio of time to second failure versus time to first failure was, on average, approximately 1.4 [i.e. $E(X_2/X_1) \doteq 1.4$], but for these data it was noted that the initial three or four failures were all within that ratio and that the first and second failures were right on top of each other. An estimate of this sample of data gave a value of $\hat{\kappa}' = 0.12$, which was considerably below the rest of the variable-amplitude data, where $\hat{\kappa}' = 0.19$. However, because no obviously acceptable reason was available for the rejection of these data, they were retained in the variable-amplitude sample.

Figure 13 plots the simple monolithic unnotched data, bonded joints data, and low-amplitude/high-life fatigue performance data. It is obvious that these results are substantially different from those given by the qualified data, and they were consequently disqualified as being untypical of the variability expected from aluminum aircraft structures. Furthermore, it could be argued that laboratory-type unnotched specimens were sufficiently different from structural details containing a multitude of holes and discontinuities that their worth as a test specimen was doubtful. The bonded data came from some older reports, which

exhibited some inconsistencies in the bonding process and thus contained test results with extremely early failures and therefore large scatter. Finally, low-amplitude/high-cycle data reflect the effects of the endurance limit where the shallow slope of the S-N curve tends to exaggerate any differences in the test loading. The airplane structure is designed for more finite lifetimes, and the exaggerated scatter of the very-long-lived tests would be unrepresentative of this design parameter. The comments enumerated above add some further justification for neglecting these data from the estimation of the typical shape parameter.

Having observed the large scatter of the data from high-life testing, the remaining mass of data was examined to check for any trends showing increase in scatter with increase in cyclic lives. The range of data between 70 and 10^6 cycles of constant-amplitude loading was broken into five ranges that were considered of general interest to the designer, and estimates of the shape parameter were conducted for these ranges. Figure 14 shows these results and demonstrates that within the broad range of 70 to 10^6 cycles fatigue scatter does not increase with cyclic life. However, above and below this range scatter was noted to increase, which could be expected considering the flat tails at either end of the S-N curve.

These analyses of the mass of collected data have revealed several important facts regarding the fatigue scatter of aluminum alloys. They have shown that, with <u>certain specific restrictions</u>, fatigue scatter did not vary with:

1) The material of the aluminum alloy specimen
2) The geometry of the notched specimen
3) The cyclic life of the specimen
4) The fatigue test machine
5) The type of loading (whether constant or variable amplitude)

Actually, a trend toward <u>marginally</u> lower scatter was observed from variable-amplitude data when compared with constant-amplitude data, but, because the variable-amplitude data contained considerably fewer samples, further work would be necessary to make any more of this slight trend.

It is realized that these results do not substantiate some published conclusions (Refs. 23 and 24) that were based on a limited amount of test data of which many were judged to be untypical of aluminum structures. It should be emphasized that conclusions made about population parameters must be generated from a background that is sufficiently large to reduce the problem of both systematic and sampling error, and it is believed that this current investigation has taken a major step toward this goal.

c. Comparison of Empirical and Theoretical Sampling Distributions

During the analysis of the data an observation had been made of the great preponderance of samples of size two, three, four, and five specimens. These individual groups were examined more closely to circumvent the problem of weighting information from groups of differing

sample size. Table VII presents the results of the three analyses conducted: (1) the MLE procedure for data that include high-time-outliers, (2) the ad hoc high-time-outlier censoring procedure, and (3) the two-ordered-failure estimator. The tabulated results demonstrate the improvements in the estimates of κ that were obtained by the censoring of data containing high-time outliers. The samples of size two could not be censored, for obvious reasons, and therefore do not alter, but the remaining groups all reflect lower scatter with rejection of the high-time outlier and follow a consistent trend regardless of the censoring method used.

Figures 15 through 18 show plots of the percentage frequency and cumulative frequency of $\hat{\kappa}$ for samples of two to five specimens. These empirical distributions have been compared with the theoretical cumulative sampling distributions that were determined from Eq. (IV-13) by using the value of $\hat{\kappa}'$ for the 1,298 groups of qualified data, that is, $\hat{\kappa}' = 0.224$. (See Table VII.) All four figures exhibit the same trends, a similarity of the empirical and theoretical curves, with the data showing slightly less conservatism than that predicted by theory, except at the higher percentiles where a crossover of the curves is observable.

To compensate for this latter behavior it was necessary to adopt some interval estimate of the shape parameter, and a 95% confidence level was assumed to provide as severe an interval as desirable. The qualified data were of such a considerable mass that the resultant deviation of the collective estimator was very small, being in the order of 0.006. As nothing further was known about the distribution of the estimate, the Tchebycheff inequality, which leads to the statement $P\ (\kappa < \hat{\kappa}'_{\gamma}) > \gamma$, was used for establishing the desired upper bound, $\hat{\kappa}'_{\gamma}$. This resulted in a value of $\hat{\kappa}'_{0.95} = 0.25$, and curves generated from this number have also been plotted in Figs. 15 through 18. These plotted curves help demonstrate the expected improvement in reliability to be gained by using the interval value of $\hat{\kappa}'$, and it can be seen from the proximity of the theory curves of the weighted mean value and the interval value of $\hat{\kappa}'$ that the added conservatism given by the interval estimate should not result in an excessive increase in the overall "scatter factor."

Figures 19 through 24 are plots of the percentage frequency and cumulative frequency of $\hat{\kappa}$ for specific sample sizes from the total mass of collected data. These have been included to facilitate comparisons between the total collected data and that finally qualified as typical of aluminum aircraft structures. A comparison of these graphs with Figs. 15 through 18 demonstrate the greater divergence between the empirical and theoretical curves for the total data. This is further accentuated by observing the much closer correlation of the sample mean values with the average mean value given in the plots of the qualified data in Figs. 15 through 18. These trends are further verification of the improvement (i.e. reduction) in systematic error that was obtained through rejection of specific data.

Table VIII has been included to substantiate the improvement gained by the editing of the total mass of collected data to exclude those considered to be untypical or unrepresentative of aluminum structural behavior. The results tabulated include the sample size, the number of groups, the estimated value $\hat{\kappa}$; the variance of the observed distribution of $\hat{\kappa}$; and then two theoretical variances, the first based on the individual estimate of κ and the second calculated from the overall weighted average estimate $\hat{\kappa}'$ obtained from all the qualified fatigue performance data. The initial results presented are comparisons of the observed and theoretical values for samples of size two, three, four, and five obtained from an examination of all the collected data. It is obvious from these results that the observed variance was greater than that predicted by theory. The remaining results were obtained from only the data that were qualified as typifying current structural performance, and it can be seen that the observed variance has now reduced to almost the equivalent value as was obtained theoretically. A further comparison of the empirical variance with the theoretical variance obtained from the weighted average value of $\hat{\kappa}'$ also shows a good correlation for the qualified data but a rather poor agreement for the total collected data.

4. DETERMINATION OF SCATTER FACTORS

Table VII gives the results of the analyses conducted on fatigue performance data. The two methods used for compensating for the influence of high-time outliers within certain groups of data resulted in two slightly different estimates of κ, namely: $\hat{\kappa}' = 0.2416$ for the MLE method using all the data points and $\tilde{\kappa}' = 0.2244$ for the two-ordered failure estimating method. Naturally these two estimators are weighted differently; the deviation of the former was approximately 0.003, whereas the latter was approximately 0.006. Using these values, interval estimates of κ were established at the 95% confidence level through the Tchebycheff inequality, and the resultant values were found to be almost identical at: $\hat{\kappa}'_{0.95} = 0.2575$ and $\tilde{\kappa}'_{0.95} = 0.2525$

As a consequence of this equality in the results it was decided to adopt the first-two-ordered-failures estimating procedure for the following reasons:

a) Ease of computation (does not require iterative techniques)
b) Handles the problem of the high-time outlier without resorting to heuristic techniques
c) Is an order-statistic approach to the problem

Having established an upper bound for the Weibull shape parameter at $\tilde{\alpha}'_{0.95} = 4.0$ (i.e. $\tilde{\kappa}'_{0.95} = 0.25$) for all typical aluminum airplane structure, it is possible to study the effects of the variables that combine to produce the "scatter factor." In this report, scatter factor is defined as the ratio of the tested or calculated average or characteristic life versus the design or certifiable life. The scatter-factor variables proposed in this report are defined as:

a) The sample size factor S_{n_f}, which regulates for the improvement in the estimates of the scale or location parameter that result from increasing the test input information from a single failed specimen to an infinite number of data points.

b) The reliability factor $S_{\bar{R}}$, which provides the relationship between some level of performance (e.g. mean or characteristic life) and the performance at the desired level of safety for a fleet of one.

c) The fleet size factor $S_{N_{\bar{R}}}$, which compensates for the decreasing reliability caused by varying the fleet exposure from a single to a multiplicity of units.

The proposed scatter factor is the product of these three variables:

$$\text{Scatter Factor (S)} = S_{n_f} \cdot S_{\bar{R}} \cdot S_{N_{\bar{R}}}$$

The arguments for this approach have already been presented in Sec. II, and the analytical definition of this reliability plan is given in Sec. V.

Table IX has been presented to illustrate the relative influence of any one variable on the overall scatter factor. The characteristic life is the Weibull scale parameter β, which is estimated by using the MLE equations on the results of full-scale structural fatigue tests. The values presented for the variation of sample size (i.e. S_{n_f}) include the factor for converting the point estimate of $\hat{\beta}$ to a one-sided lower bound estimate at the 95% confidence level. It is readily apparent from the table that only a small penalty is incurred by testing the minimum number of full-scale developmental tests. However, it is equally obvious that the reliability specification and fleet size are critical components on the final magnitude of the scatter factor and therefore require careful consideration when establishing a desired performance goal.

5. APPLICATION OF RELIABILITY ANALYSIS TO AIRPLANE STRUCTURES

a. Example Problems

The proposed reliability analysis plan has been applied to a few structural details for which both full-scale laboratory test results and actual service performance data were available. The airplane considered was a military, jet-engined tanker/transport-type aircraft of approximately 300,000-lb maximum gross weight.

The <u>first</u> example concerned a trailing-edge discontinuity detail on the wing lower surface. From full-scale structural test:

- Time to detected crack = 3,697 spectra on starboard wing only
- Equivalent flight time per load spectrum application = 5 hours
- Time to first detected crack = 18,500 hours

A retrofit package planned to extend the service life had been initiated and, as of January 1969, 268 airplanes of the same particular type had been inspected and modified. Low time for a crack out of this group of inspected airplanes = 2,720 hours.

A comparison of the current fatigue evaluation method and the proposed reliability analysis method is itemized below:

1) Arbitrary scatter factor of 4
   - Test life = 18,500 hours
   - Safe life = 18,500/4 = 4,600 hours
2) Reliability analysis
   - Test life on starboard wing = 18,500 hours and the port wing > 18,500 hours
   - Test characteristic life = 22,000 hours

$$\text{from } \hat{\beta} = \left[\frac{1}{n_f} \sum_{1}^{n_f} Y_i^{\alpha} + (n-n_f)\, Y_{(n_f)}^{\alpha} \right]^{1/\alpha} \qquad \text{(V-2)}$$

   and from Table IX:

   Test sample size = 1 failure $S_{n_f} = 1.32$
   Fleet size (268 airplanes) = 536 wings $S_N = 4.81$
   Reliability of mean life of weakest $S_{\bar{R}} = 1.102$
   75% reliability of weakest $S_{\bar{R}} = 1.365$

   - Mean life of weakest of fleet, therefore, = 22,000/7.0 = 3,140 hours
   - 75% reliability of weakest of fleet, therefore, = 22,000/8.7 = 2,530 hours

However, several other structural details were also inspected and modified during installation of the previously mentioned retrofit package, and these results--together with that just given in the example--are tabulated in Table XI. The expected performance given by the reliability analyses and based on test lives of the details or calculated performance based on a test result, all at the 95% confidence level, are also compared. The several differing versions of the reference tanker/transport airplane were examined and are also included in the table. It is immediately obvious that the proposed scatter factors vary widely on both sides of the current value of 4, depending on the size of the exposed fleet and, consequently, estimate safe lives that are different from those currently computed. It is also obvious that the fatigue improvement packages were installed at times that were based on scatter factors ≥ 4.

A second example again concerns wing structure in which skin cracks were discovered at a critical skin/doubler detail. From the full-scale structural test:

- Time to detected crack = 1,498 spectra on starboard wing only
- Equivalent flight time per load spectrum application = 5 hours
- Time to first detected crack = 7,500 hours

Low-time failure in fleet = 655 hours

A comparison of the current fatigue evaluation method and the proposed reliability analysis method is itemized below:

1) Arbitrary scatter factor of 4
   - Test life = 7,500 hours
   - Safe life = 7,500/4 = <u>1,875 hours</u>

2) Reliability analysis
   - Test life on starboard wing = 7,500 hours and the port wing > 7,500 hours
   - Test characteristic life = 8,920 hours [(from Eq. (V-2))]

     and from Table IX:

Test sample size = 1 failure	S_{nf}	= 1.32
Fleet size (500 airplanes) = 1,000 wings	S_N	= 5.63
Reliability of mean life of weakest	$S_{\bar{R}}$	= 1.102
75% reliability of weakest	$S_{\bar{R}}$	= 1.365

   - Mean life of weakest in fleet, therefore, = 8,920/8.2 = <u>1,100 hours</u>
   - 75% reliability of weakest of fleet, therefore, = 8,920/10.1 = <u>880 hours</u>

It is readily apparent that the order-statistic application of reliability analysis forecasts a minimum service life that is recognizably less than the conventional approach. Most noteworthy is the closer approximation of actual service data by this proposed approach. An obvious hazard of the proposed reliability analysis plan is its total dependence on the test result, with its assumed equality of test and service environment. It is imperative, therefore, that as accurate and reliable an approximation to service conditions as is practical be considered in establishing the characteristic life of the structure. At this time, however, the actual correlation between service and prediction seems promising.

One further point regarding the preceding examples concerns the choice of degree of reliability of the weakest members. If it is extremely important that the weakest members be guarded against the likelihood of failure, some reliability interval other than median or mean should be considered. A 75% level of reliability was also assumed in the preceding examples for demonstrative reasons only and not as a suggested value for the reliability interval. It can be seen, however, that even this fairly low specification would have proved adequate for predicting the failure in the first example and approached the performance level of the weakest in the second example. It should be added that the second example, although a fatigue failure, had been aggravated by poor initial assembly, thus causing an extremely early failure.

b. Possible Design Penalty From Application of Reliability Analysis Plan

Some additional work was completed to provide a measure of the penalty that might be incurred by the introduction of this proposed reliability analysis. Fatigue performance analyses were conducted at several fatigue critical locations on the jet-engined military tanker/transport aircraft referred to earlier in the discussion. A typical

5-hour mission profile was used in conjunction with gust and maneuver data that had been reduced from SAC VHG data measured on the reference airplane at Castle and Walker Air Force Bases (Ref. 25). Figures 25, 26, and 27 describe the mission profile, gust data, and maneuver data respectively. Reference locations were selected from each of the major components of the airframe and comprehensive fatigue damage analyses conducted to determine their respective performances. These analyses were based on the Palmgren-Miner fatigue damage hypothesis together with stress versus cyclic life data obtained from fatigue tests on full-scale structural components. An example family of S-N curves is shown in Fig. 28. Figure 29 was plotted from the results of the computations and describes the gain in fatigue performance obtained by the reduction in the gross allowable design stress.

At this time weight estimates were conducted for all fatigue-critical primary structure on the reference airplane, and the increase in structural weight for a given reduction in gross allowable stress was determined. With this information and the stress increment versus life increment data given in Fig. 29, it was possible to study the effects of the reliability analysis on design weight and then, by reference to Fig. 30, to translate this into the effects on payload or range.

Figure 31 gives the relationship between reliability and weight increase for a structural component designed by fatigue considerations, whereas Fig. 32 shows a plot of the percent increase in structural weight versus the level of reliability of the weakest airplanes in a fleet of 600 aircraft. The initial weight of the airplane reflects current design practice, which includes the scatter factor of 4 for fatigue-critical structure. The increase in weight results directly from the increase in the scatter factors as computed from Table IX. These values were normalized to the current factor of 4, and the resultant ratios represent the increased life factors required by the proposed reliability analysis. Any of the reference structural locations that were examined during this study and that did not meet these new criteria had their gross stress lowered sufficiently to meet them, and the increase in structural weight was subsequently computed. It should be realized that major structural airframe components may have quite different fatigue performance capability, as some components may be almost entirely designed by fatigue considerations, whereas other locations have to meet static requirements primarily, but also have built-in fatigue capacity. As a consequence of these design requirements all the reference components that were analyzed were not found to be equally penalizing, and the plotted curves showing weight increase with specified reliability (Fig. 32) reflect this aspect of aircraft structural design.

One other very important assumption made for this weight increase study needs further clarification. It was considered essential that in order to test the feasibility of the reliability analysis an upper bound condition was necessary to determine the maximum penalty that could be incurred by this proposed approach. Consequently, it was assumed that

the only way of meeting the new design goal was by lowering the gross design stress for all structural components that were both fatigue oriented and related to the reference locations that had been affected by the new analysis. This is obviously a pessimistic assumption, as no allowance was made for the possibility of reaching the revised goal by a redesign or modification of the existing detail structure. Nevertheless, Fig. 32 demonstrates that, even for this upper bound condition, a weight penalty of 3.6% of the primary structural weight was sufficient to provide a median reliability on the weakest of a fleet of 600 airplanes, and as much as 95% reliability was obtained by a 7% increase in the weight of the primary structure.

The lower curve on Fig. 32 represents the maximum weight penalty that would be incurred if the designer were to specify reliability on the second failure in the fleet. This plotted result was based on the values presented in Table X, which tabulates scatter factors for the second failure of a fleet. It is immediately obvious from a comparison of the weight plots that if a criterion based on the second failure were acceptable, a much lower weight penalty would be incurred. For example, it can be seen that the weight increment that would provide median reliability of the weakest member in 600 airplanes would also result in an 80% level of reliability of the second weakest. Putting this another way, a design criterion based on the second failure of the fleet would require about two-thirds of the weight increment necessary for the same level of reliability of the first failure in the fleet.

The plots in Fig. 30 give the percent decrease in payload and range respectively versus percent increase in structural weight. These plots were used to develop Figs. 33 and 34, which show the decrease in payload or range versus degree of reliability of the weakest airplanes in a fleet of 600. As in Fig. 32 the upper and lower curves represent the penalty incurred by specification of the first or second failures respectively and, as before, an effective lowering of the required additional weight is demonstrated. The maximum payload condition used in this analysis amounts to approximately 27.5% of the gross weight of the reference airplane. It is obvious that the plotted results of payload versus reliability are intrinsically dependent on this figure and that other airplanes of greater or lower payload capability would be affected either less or considerably more than the reference airplane. However, although this argument is undoubtedly true, it should be remembered that the particular airplane was chosen because of the availability of specific data and without prior knowledge of the outcome.

It must be reemphasized that these studies are limited to aluminum structures only, as the reliability analysis can account for only this material at the present time. However, the large majority of the airplane structure is composed of this material and consequently it is believed that the results presented are representative of the entire airplane and serve to demonstrate the feasibility of the proposed reliability plan.

To further illustrate the application of the reliability plan, it is assumed that:

- Airplane average life = 40,000 hours
  then, under present criteria,
  safe life = 40,000/4 = 10,000 hours
- Scatter factor from reliability estimate obtained from Table IX:

$$\left.\begin{array}{ll} S_{n_f} & = 1.32 \text{ (for one test detail)} \\ S_N & = 4.96 \text{ (for N = 600)} \\ S_{\bar{R}} & = 1.102 \text{ (mean life)} \end{array}\right\} \quad S = 7.2$$

- Mean life of weakest = 40,000/7.2 = 5,600 hours
- Ratio of life = 10,000/5,600 = 1.79

That is, the Weibull-distribution-based reliability criterion requires a 79% increase in life to compare with the currently specified value of 10,000 hours. From Fig. 29, a 79% life improvement requires a 15% reduction in stress, which translates into a 3.6% increase in structural weight, as shown in Fig. 32.

In other words a 3.6% increase in structural weight would be sufficient to provide enough reliability that the mean performance of the weakest of a fleet of 600 airplanes would equal or exceed 10,000 hours. Furthermore, this increase in structural weight translates into a 2.8% decrease in payload or a 3.0% decrease in range for the type of airplane under consideration. Most importantly, it should be reemphasized that the number of exposed details (i.e. fleet size) as well as the number of test details demonstrating the fatigue performance level are the significant elements of this reliability approach.

6. RELIABILITY ANALYSIS BASED ON THE LOG-NORMAL DISTRIBUTION

a. Results of Data Analyses

Historically the log-normal distribution has been accepted as a reasonable distribution function for fatigue life even at small probabilities of failure. Consequently, it is a very familiar tool within the aircraft industry and as such has been the basis of many past and present assessment techniques. Furthermore, a great deal is known about estimating and establishing confidence bounds for the two normal parameters, especially for uncensored samples. For these reasons it was decided that the log-normal model merited investigation as a possible basis for a reliability analysis.

The approach used parallels the work described in the preceding discussion on the Weibull distribution, except that the two-ordered-failure-estimation procedure was not extended to the log-normal model. This does not imply that the work accomplished with this distribution model was inferior to that performed with the Weibull model but simply that the timely application of order statistics was not possible for estimating the shape parameter of the parent population. As a result this was obtained by the MLE procedure (Ref. 26) after censoring of data that contained high-time outliers.

The results of the point estimates of the shape and scale parameters are given in Appendix II, and the estimates of the weighted average values of shape parameter are summarized in Table XII. These tabulated results demonstrate trends similar to those observed for the Weibull model, namely, an improvement in the magnitude of the answers with the censoring of the high-time outliers. This effect is illustrated in Figs. 35 through 38. These are plots of the percentage frequency and cumulative frequency distributions of the unbiased shape parameter σ for the samples of size two to five specimens that do not contain high-time outliers. Cumulative frequency plots for data that have not been censored for high-time outliers are compared on these figures and can be observed to exhibit greater scatter.

Figures 39 through 42 are plots of the empirical and theoretical sampling distributions for the same groups of size two to five specimens. These theoretical curves have been generated from the weighted average value of all the qualified data, that is, $\bar{\sigma} = 0.135$. (See Table XII.) An interval estimate of this point value was calculated from assumptions of normality and was found to be $\bar{\sigma}_{0.95} = 0.14$. The normal assumption was justified, for it was known that the estimate followed a χ^2-distribution, which reduced to normality because of the very large data sample. It is worth mentioning that as a result of the weighting techniques used in this analysis, the 1,121 groups of data used in estimating the above values of the shape parameter are theoretically the equivalent of a test sample containing in excess of 3,500 data points. Curves representing the 95% confidence upper bound value have been included in Figs. 39 through 42. These figures demonstrate that the empirical and theoretical values are similarly distributed but that the theoretical values are displaced toward slightly higher scatter except at the upper percentiles.

Figures 39 through 42 show that the sample averages were higher than the interval estimate given by all the qualified data, even though only 15% of the data was distributed to the right of the values predicted by theory. However, these data result in increasing the estimated weighted average value of the shape parameter, especially as the estimation procedure used for the log-normal model computes the variance rather than the shape parameter. It is believed that the direct estimation of the unbiased shape parameter rather than the traditional procedure of taking the square root of the unbiased variance would result in a slight lowering in the value of the average shape parameter and consequently an improvement in the proximity of the empirical and theoretical distribution plots. This expected trend can be demonstrated by referring to Figs. 43 and 44, which are the plots of the Weibull shape parameters obtained by the MLE procedure. A comparison of these graphs with Figs. 40 and 41 demonstrates similar behavior, except that the Weibull empirical and theoretical curves are in closer proximity than those for the log-normal case. This explanation does not preclude the additional possibility that part or all of the improved fit is inherent to the Weibull model itself.

In keeping with the procedures described earlier for the Weibull model, scatter factors were computed based on the interval estimate $\sigma'_{0.95}$ = 0.14. As before, factors were generated for the influence of sample size, degree of reliability, and fleet size factor, and are tabulated in Tables XIII and XIV to illustrate the relative importance of the three variables. These factors are noted to be of relatively equivalent weight, unlike the Weibull model in which only a small penalty can be attributed to the lack of an infinitely large test sample. It is also obvious that the factors are generally of a lower order than the equivalent Weibull values and that they do not increase as rapidly with expanded fleet sizes or higher reliability.

b. Example Problems

The examples worked out on pages 21, 22, and 23 may now be reevaluated using assumptions of log-normality.

The first example concerned a trailing-edge discontinuity detail. From full-scale structural test: Time to first crack = 18,500 hours and low-time failure in 268 inspected airplanes = 2,720 hours. From Table XIII:

Test sample size = 1 failure	S_n = 1.70
Reliability of median life of weakest	$S_{\bar{R}}$ = 1.0
Fleet size of 268 airplanes	$S_{N_{\bar{R}}}$ = 2.50

then median life of weakest of fleet = 18,500/4.25 = 4,350 hours
and current method computes safe life = 18,500/4.0 = 4,600 hours

The second example concerned a critical skin/doubler detail. From full-scale structural test, time to crack = 7,500 hours and low-time failure in 500 airplanes = 655 hours. From Table XIII:

Test sample size = 1 failure	S_n = 1.70
Reliability of median life of weakest	$S_{\bar{R}}$ = 1.00
Fleet size of 500 airplanes	$S_{N_{\bar{R}}}$ = 2.65

then median life of weakest of fleet = 7,500/1.70 x 1.0 x 2.65
= 1,670 hours
and current method computes safe life = 7,500/4.0 = 1,875 hours

It is again apparent that despite a change in the assumed distribution to the log-normal model, the results still demonstrate the lower order of reliability that can be expected by application of the arbitrary scatter factor of 4, that is, less than 50% reliability on the weakest members of a large fleet.

One additional item needs further discussion, namely, the technique used in establishing the mean life of the respective details. A comparison with the earlier examples on pages 21, 22, and 23 shows that in the former case account was taken of the failed and unfailed starboard and port test wings, whereas in the log-normal case the wing was considered as one total unit. This was a necessity at this time, for although tools are available for obtaining point estimates from censored data of limited sample size

their bias and variance are not known and hence it is not currently possible to determine a suitable interval estimate. However, the test was considered as a complete sample and by adopting the same criterion for the fleet- that is, each airplane has one complete wing--it was possible to work the problem.

SECTION IV

MATHEMATICAL RESULTS FOR SHAPE-PARAMETER ESTIMATION

The mathematical results necessary to obtain a numerical estimate of aluminum alloy structural fatigue "scatter" are listed and briefly described in this section. With reference to the schematic (Fig. 2) of the reliability analysis, this section corresponds to the second stage of the plan. Unlike the third, fourth, and fifth stages, this part of the analysis, once completed, does not have to be repeated for subsequent applications.

1. STATEMENT OF THE PROBLEM

From a large number of small samples of applicable fatigue data obtain a precise one-sided confidence interval estimate of the distribution shape parameter for both the Weibull and log-normal time-to-failure models.

2. GENERAL SOLUTION

It must first be assumed that the k selected samples of data come from populations with different scale parameters but equal shape parameters when applying either the Weibull or log-normal model. The error in this assumption may be evaluated at the conclusion of the exercise by comparing the theoretical sampling distributions of the shape-parameter estimator with the observed distributions of the data estimates.

Because of the above assumption the estimators of the shape parameter used must be invariant estimators, that is, independent of the scale-parameter values. Since the large number of estimates of the various data groups or samples can be averaged to obtain one comparatively accurate estimate, it is obviously advisable to work with unbiased estimators.

In addition to these reasons, invariant unbiased shape parameter estimators will be used so that the following important theorem,[2] stated without proof, can be applied to provide interval estimates.

Theorem: Let $\hat{\lambda}_i$ be an unbiased invariant estimate of the true parameter λ from the i^{th} of k data groups. If the variance of $\hat{\lambda}_i$ is equal to $Q_i \lambda^2$, then the estimate

$$\hat{\lambda}' = \frac{\sum_{i=1}^{k} \lambda_i/Q_i}{\sum_{i=1}^{k} 1/Q_i} \qquad \text{(IV-1)}$$

is an unbiased estimate of λ with variance

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[2] Refer to Mann (Ref. 17, p. 643) for a different usage of this theorem.

$$\mathrm{Var}\,(\hat{\lambda}') = \frac{\lambda^2}{\sum_{i=1}^{k} 1/Q_i} \qquad \text{(IV-2)}$$

Equation (IV-1) is being used to obtain point estimates of the shape parameters from k selected subsets. By combining Eqs. (IV-1) and (IV-2) and using the Tchebycheff inequality (since the distribution of $\hat{\lambda}'$ is not generally known) we obtain precise bounds for λ given by

$$P\left(\frac{\hat{\lambda}'}{1 + C_\gamma} \leq \lambda \leq \frac{\hat{\lambda}'}{1 - C_\gamma}\right) \geq \gamma \qquad \text{(IV-3)}$$

for $C_\gamma \leq 1$ where

$$C_\gamma = \left[(1-\gamma) \sum_{i=1}^{k} (1/Q_i)\right]^{-\frac{1}{2}} \qquad \text{(IV-4)}$$

Equation (IV-3) will be used in conjunction with all shape-parameter "subestimates" to pinpoint an accurate, but still conservative, value of the shape parameters for use in the reliability assessment plan.

3. SHAPE-PARAMETER ESTIMATORS TO EVALUATE STRUCTURAL FATIGUE SCATTER

Three methods for estimating fatigue scatter have been employed in conjunction with the Weibull model. These are:

a) The two-order-statistic estimator in which only the two lowest failure times in each qualified group of data are used to estimate κ.

b) The maximum-likelihood estimator with censoring in which all failure times in qualified complete samples are used except those high times judged, by the previously specified procedures, to be outliers

c) The maximum-likelihood estimator without censoring in which all failure times in complete samples are used to estimate κ.

Estimators of the type corresponding to the categories in b and c were also employed to estimate σ, the log-normal shape parameter. It probably would have been enlightening to devise and apply a useful two-order-statistic estimator for the log-normal model if time had permitted.

It is emphasized that in all cases the bias, variance, and sampling distributions of these invariant estimators were required and were calculated by means of existing theory, when possible, or by means of Monte-Carlo simulation adopted for this study.

4. WEIBULL TWO-ORDERED-STATISTIC ESTIMATOR

All statistical analyses in this project have been directed toward estimating the earliest failure times in a fleet and, accordingly, it is pertinent to consider estimating the scatter itself from only the earliest two failures in each of the selected groups of data. Since it has been demonstrated (Sec. III) that the Weibull estimates are most affected by relatively unimportant high-time outliers, it is especially relevant to estimate the Weibull shape α from the first and second time-to-failure order statistics. This approach should be nearly insensitive to the effects of high-time outliers that cannot be explained by the Weibull model. The final weighted two-failure estimate will be compared with the weighted likelihood estimate using all the data both with and without the arbitrary procedure for censoring outliers described in Sec. III.

As explained before, a best unbiased invariant estimator of κ is sought so that Eqs. (IV-1) and (IV-3) may be used to obtain a weighted average. Following is an outline of the derivations, developed by Mann (16), of:

a) The estimator itself [Eq. (IV-12)]

b) The sampling distribution of the estimator [Eq. (IV-13)]

c) The variance of this sampling distribution [Eq. (IV-14)]

Let $X_{1,n}$ and $X_{2,n}$ be the first- and second-ordered observations respectively from a sample of n independent Weibull random variables, each with frequency function

$$f(x) = \frac{\alpha}{\beta} \left(\frac{x}{\beta}\right)^{\alpha-1} \exp\left[-\left(\frac{x}{\beta}\right)^{\alpha}\right] \text{ for } x > 0 \qquad \text{(IV-5)}$$

where α, $\beta > 0$ are the parameters of the distribution.

Given Eq. (IV-5), the joint density of the first- and second-order statistics can be derived and is given by

$$f(x_{1,n}, x_{2,n}) =$$

$$\frac{n!}{(n-2)!} \left(\frac{\alpha}{\beta}\right)^2 (x_{1,n} \cdot x_{2,n})^{\alpha-1} \exp\left\{-\frac{1}{\beta}\left[x_{1,n}^{\alpha} + (n-1)\, x_{2,n}^{\alpha}\right]\right\} \qquad \text{(IV-6)}$$

where: $0 < X_{1,n} \leq X_{2,n} < \infty$

The density of the scale invariant statistic $Z_n = X_{2,n}/X_{1,n}$ can be derived from Eq. (IV-6) as

$$g(z) = \frac{n(n-1)\ \alpha\ z^{\alpha-1}}{[1 + (n-1)z^{\alpha}]^2} \qquad \text{for } z \geq 1 \qquad \text{(IV-7)}$$

It follows that the distribution of Z_n is

$$G(z) = P\ (Z_n < z)$$

$$= n \int_1^{z^{\alpha}} \frac{(n-1)\ du}{[1 + (n-1)\ u]^2} = 1 - \frac{n}{1 + (n-1)z^{\alpha}} \qquad \text{(IV-8)}$$

Since Z_n has scale invariance, it follows that any estimator of $\kappa = 1/\alpha$ that is a function of Z_n alone is also invariant. Mann (16) has derived the maximum-likelihood estimator of κ from the first two of n failures and found it to be expressible in the form

$$\hat{\kappa} = u_n\ \ln Z_n \qquad \text{(IV-9)}$$

where the coefficient u_n depends only on n. This led Mann to consider all estimators of the same general form as in Eq. (IV-9), namely, the product of a constant depending on n and $\ln Z_n$. Among these estimators there is only one unbiased invariant estimator $\tilde{\kappa}$, and it may be expressed as

$$\tilde{\kappa} = b_n\ \ln Z_n \qquad \text{(IV-10)}$$

so that the coefficient b_n is given by

$$b_n = \frac{\kappa}{E\ (\ln Z_n)}$$

It should be noted now that there is no difference between this unbiased two-ordered statistic estimator $\tilde{\kappa}$ and the unbiased likelihood estimator $\hat{K}$, which will be introduced later, provided that $\hat{K}$ is calculated at the second observed failure time. However, there will generally be a small numerical difference since the to-be-discussed coefficients B_n are determined approximately by computer simulation, whereas the coefficients b_n can be calculated exactly from the results that follow.

$$\text{The expectation of } \ln Z_n = \int_1^{\infty} \ln z \; g(z) \; dz \qquad \text{(IV-11)}$$

After several intermediate steps (not shown here) the right side of Eq. (IV-11) can be integrated to obtain

$$E(\ln Z_n) = n \ln \left(\frac{n}{n-1}\right) \kappa$$

so that

$$b_n = \frac{1}{n \ln \left(\frac{n}{n-1}\right)}$$

Therefore, the desired best invariant unbiased estimator $\hat{\kappa}$ of κ has been completely determined as

$$\hat{\kappa} = \frac{\ln Z_n}{n \ln \left(\frac{n}{n-1}\right)} \qquad \text{(IV-12)}$$

The distribution of $\hat{\kappa}$ is calculated from Eqs. (IV-8) and (IV-12) as

$$P (\hat{\kappa} < t) = 1 - \frac{n}{1 + (n-1) \left(\frac{n}{n-1}\right)^{\frac{nt}{\kappa}}} \quad \text{for } t > 0 \qquad \text{(IV-13)}$$

Mann has also calculated the expectation of $\ln^2 Z_n$ and subsequently the variance of $\hat{\kappa}$ as

$$\text{Var} (\hat{\kappa}) = b_n^2 \left[2 \; n \; R\ell \left(\frac{n}{n-1}\right) - \frac{1}{b_n^2} \right] \kappa^2 \qquad \text{(IV-14)}$$

where $R\ell$ (x) is Spence's integral with argument (x), which can be evaluated from the power series

$$R\ell \; (x) = - \sum_{j=1}^{\infty} \frac{(1-x)^j}{j^2} \quad \text{for } x \geq 1$$

Equations (IV-12) and (IV-14) have been used with the weighted average-type estimators in Eqs. (IV-1) and (IV-3) to determine κ. Equation (IV-13), the theoretical distribution of the subestimator $\hat{\kappa}$, has been compared with the observed distribution of the data group estimates in Figs. 15 through 18. The resulting close fit between theory and observation attests to small error in the initial assumption regarding the existence of a unique value of κ that controls the scatter of fatigue lives.

5. WEIBULL MAXIMUM-LIKELIHOOD ESTIMATOR

Prior to application of the two-ordered-statistic type of estimator to minimize the problem of high-fatigue-life outliers, an estimation procedure was sought that would best account for all fatigue life observations in each sample. The MLE was a suitable choice since, for general application, it provides either a best estimate, or nearly so, and for specific application to Weibull shape estimation it outperforms all investigated alternatives. (Refer to Ref. 18.)

On this basis, when high-life outliers do not occur, which has apparently been the case in tests on large multidetailed components, the MLE is recommended for pinpointing the shape-parameter value. However, since the vast majority of the data consists of small, monolithic specimens of the type that contains a minority of definite high outliers, the two-ordered-statistic estimator was relied on in this work to obtain the estimate of κ most relevant to the lower portion of the fatigue life distribution.

As discussed before, this two-ordered-statistic estimator is simply a special case of the MLE where all fatigue life observations in a sample have been ignored except for the two lowest. In view of this relationship and because the problem of high-time outliers may be coped with in any number of other ways (such as by looking at all observations except those judged to be outliers), it was considered worthwhile to discuss some MLE results obtained during this task and prior to application of the order-statistic approach.

a. Weibull MLE Equations

The derivation of the estimators given below for α, $\beta > 0$ was first given by Cohen (13) and, for completeness, is included in Appendix I.

$$\frac{\sum_{i=1}^{n_f} X_i^{1/\hat{\kappa}} \ln X_i + \sum_{i=1}^{n_g} G_i^{1/\hat{\kappa}} \ln G_i}{\sum_{i=1}^{n_f} X_i^{1/\hat{\kappa}} + \sum_{i=1}^{n_g} G_i^{1/\hat{\kappa}}} - \hat{\kappa} = \frac{1}{n_f} \sum_{i=1}^{n_f} \ln X_i \qquad \text{(IV-15)}$$

$$\check{\beta} = \left[\frac{1}{n_f}\left(\sum_{i=1}^{n_f} X_i^{1/\hat{\kappa}} + \sum_{i=1}^{n_g} G_i^{1/\hat{\kappa}}\right)\right]^{\hat{\kappa}} \qquad \text{(IV-16)}$$

Equation (IV-15) is not explicit in $\hat{\kappa}$ and must be solved by an iterative procedure for each new data sampling. The correct value of $\hat{\kappa}$ may then be substituted into Eq. (IV-16) to obtain the MLE of the Weibull scale, termed β. This estimate β is to be used only when κ is assumed to be unknown. For the case to be considered in the next section, that of <u>known</u> κ, the following equation is applicable:

$$\hat{\beta} = \left[\frac{1}{n_f}\left(\sum_{i=1}^{n_f} X_i^{1/\kappa} + \sum_{i=1}^{n_g} G_i^{1/\kappa}\right)\right]^{\kappa} \tag{IV-17}$$

b. Sampling Distribution of Weibull MLE $\hat{\kappa}$, $\check{\beta}$, and $\hat{\beta}$

It is believed that, except for the case of $n_f = 2$ studied by Mann (16), the distributions of the MLE $\hat{\kappa}$ and $\check{\beta}$ of Weibull distribution parameters have never been calculated. However, the distribution of $\hat{\beta}$ is known precisely for samples that are either complete or censored by failure time, and its formulation is included in Appendix I.

The key to the concise description of all three sampling distributions is to express the estimator within an invariant or parameter-free statistic and to find the distribution of that statistic.

For the previously solved case of $\hat{\beta}$ it is shown in Appendix I that the known distribution of the statistic

$$W = \left(\frac{\hat{\beta}}{\beta}\right)^{1/\kappa} \tag{IV-18}$$

is independent of true values of parameters α and β. Likewise, it is shown that the unknown marginal distributions of

$$U = \frac{\hat{\alpha}}{\alpha} = \frac{\kappa}{\hat{\kappa}} \tag{IV-19}$$

and of

$$V = \left(\frac{\check{\beta}}{\beta}\right)^{1/\hat{\kappa}} \tag{IV-20}$$

do not depend on α and β. A method is then outlined in Appendix I for finding these distributions approximately through Monte-Carlo computer simulation. The results of the work, where 2,000 independent random samples were generated per distribution, are presented in Tables III and IV and in Figs. 4 and 5. Notice the excellent agreement between the empirical and the exactly known distributions of U for samples of two observations.

c. Bias and Variance of the Estimator $\hat{\kappa} = 1/\hat{\alpha}$

The bias and variance of $\hat{\kappa}$, in terms of κ, have been evaluated for several complete sample sizes from the empirical distributions of $1/U$. The results are given below in a form easily combined with Eqs. (IV-1) and (IV-3) to obtain an overall estimate of κ from all qualified complete samples:

Complete Sample Size n	Bias Factor B_n	Variance Factor Q_n
2	1.73	0.71
3	1.37	0.35
4	1.25	0.22
5	1.187	0.164
10	1.088	0.073
20	1.047	0.033
∞	1	0

where $E(B_n \hat{\kappa}) = \kappa$ and $\mathrm{Var}\,(B_n \hat{\kappa}) = Q_n \kappa^2$.

The workable subestimate is then formed by multiplying the likelihood estimate $\hat{\kappa}$ by the coefficient B_n to obtain

$$\hat{\hat{\kappa}} = B_n \hat{\kappa}$$

an invariant unbiased estimate of κ.

6. LOG-NORMAL MAXIMUM-LIKELIHOOD ESTIMATORS

Assume that the logarithm X_L of the life span is a random variable with a normal distribution, where μ, $\sigma > 0$ are the two parameters of the distribution. Cohen (26) has derived the maximum-likelihood estimators $\hat{\mu}$ and $\hat{\sigma}$ of μ and σ for incomplete samples, as given by

$$\bar{X}_L = \hat{\mu} - \frac{1}{n_f} \sum_{i=1}^{n_g} h_i$$

$$s^2 = \hat{\sigma}^2 \left[1 - \frac{1}{n_f} \sum_{i=1}^{n_g} \epsilon_i h_i - \left(\frac{1}{n_f} \sum_{i=1}^{n_g} h_i \right)^2 \right] \qquad \text{(IV-21)}$$

where h_i is the estimated hazard function or failure rate at time Z_i of one of the n_g test terminations for reasons other than failure. Thus,

$$h_i = h(\epsilon_i) = \frac{\phi(\epsilon_i)}{1 - \Phi(\epsilon_i)}$$

$$\Phi(\epsilon_i) = \int_{-\infty}^{\epsilon_i} \phi(t)\, dt$$

where: $$\epsilon_i = \frac{G_i - \hat{\mu}}{\hat{\sigma}}$$

$$\phi(t) = \frac{1}{\sqrt{2\pi}} \exp\left[-{t^2}/{2}\right]$$

and where $\bar{X}_L$ and s^2 are the mean and variance of the log lives of n_f specimens that failed; that is

$$\bar{X}_L = \sum_{i=1}^{n_f} \frac{X_{L_i}}{n_f} \text{ and } s^2 = \sum_{i=1}^{n_f} (X_{L_i} - \bar{X}_L)^2 / n_f$$

Neither $\hat{\mu}$ nor $\hat{\sigma}$ is given explicitly by Eq. (IV-21) for $n_g \geq 1$, so $\hat{\sigma}$ must be solved by an iterative procedure. For complete samples ($n_g = 0$), Eq. (IV-21) reduces to

$$\hat{\mu} = \bar{X}_L \qquad \text{(IV-22)}$$

and

$$\hat{\sigma}^2 = s^2 \qquad \text{(IV-23)}$$

The bias, variance, and sampling distributions of the estimator in Eq. (IV-23) are well known (for example, refer to Ref. 27) and are listed below:

a. Bias of $\hat{\sigma}^2$

$$E(\hat{\sigma}^2) = \frac{n-1}{n} \sigma^2$$

so that

$$E(\hat{\hat{\sigma}}^2) = \sigma^2$$

in which

$$\hat{\hat{\sigma}}^2 = \frac{n}{n-1} \hat{\sigma}^2 \qquad \text{(IV-24)}$$

b) Sampling Distribution and Variance of $\hat{\sigma}^2$

The statistic $(n-1)\ (\hat{\sigma}^2/\sigma^2)$ is parameter-free and has χ^2 distribution with (n-1) degrees of freedom and, therefore, with variance 2(n-1), so that

$$\text{Var}\left[(n-1)\ \left(\frac{\hat{\sigma}^2}{\sigma^2}\right)\right] = 2\ (n-1)$$

therefore,

$$\text{Var}\ (\hat{\sigma}^2) = \frac{2}{(n-1)}\ (\sigma^2)^2 \qquad \text{(IV-25)}$$

For the case of small, incomplete samples, the bias and variance of the estimators in Eq. (IV-21) are not known, but additional computer simulation studies could be attempted to provide these values. At this time only the complete samples and the censored samples with more than 50 observed failure times are used to estimate σ.

The resultant 0.95 confidence interval value $\sigma = 0.14$ was used in all log-normal applications that follow and, somewhat arbitrarily, for application of the Tchebycheff inequality to gage the effect of assuming no failure model.

SECTION V

INTERVAL ESTIMATION OF CERTIFIABLE LIFE FOR THE FLEET

All the estimation and probability theory corresponding to the last three steps of the analysis is discussed in this section. Referring again to Fig. 2, these steps are:

Step 3: Obtaining a most likely estimate of the distribution of fatigue lives.

Step 4: Moving back to a high confidence bound estimate of the fatigue life distribution.

Step 5: Mapping the distribution of step 4 into an order statistical distribution from which a life may be certified for the safety of all or most of the exposed fleet.

To facilitate these steps, which must be repeated with each application of the plan, all relevant equations have been translated into simple relations from which scatter-factor values may be easily calculated. The total scatter factors are henceforth defined as the ratio of one of the best estimators of central life (either $\hat{S}$, $10^{\bar{\mu}}$, or $10^{\hat{\mu}}$) and the calculated safe life $\check{Z}_{\bar{R}}$.

1. STATEMENT OF THE PROBLEM

From one sample of structural fatigue data, use a selected time-to-failure model with known shape parameter to specify a valid procedure for estimating, to any desired confidence level, either (1) the distribution of the M^{th}-ordered failure time in a fleet of size N or (2) simply the distribution of an arbitrary (unordered) failure time. Choose one of these distributions at a desired fractile to certify a design life.

2. GENERAL METHOD OF SOLUTION

To obtain as much accuracy as possible or, more precisely, to obtain uniformly minimum (mean-squared) error, maximum-likelihood point estimators of the distribution scale parameters will be used. The sampling distributions of these (unbiased) estimators are, for the most part, known so that interval estimates of the scale parameters may be calculated exactly from the point estimates.

The known shape parameter and the scale-parameter interval estimate completely determine the confidence interval bound on the distribution of unordered times to failure. Since the shape parameter is assumed to be known, this bound has the same failure distribution (Weibull or log-normal) as the point estimate, except that it is scaled backward in time by a constant multiplying factor.

The fractiles of the order-statistic's distribution may then be calculated precisely by means of the well-known cumulative binomial formula. This completes the theoretical application. A fleet life can then be estimated that corresponds to administrative specifications.

3. BEST ESTIMATE OF FATIGUE-LIFE DISTRIBUTION

With the shape-parameter value assumed known, we depend on the full-scale fatigue test to obtain the most likely value of the parent population's central tendency or scale parameter. For this reason it is recognized that the occurrence of high-time outliers in this testing could lead to overly high safe-life estimates. Fortunately, as has been observed in the data, large, complex, multicomponent specimens are not characterized by outliers to anywhere near the extent that simple monolithic specimens are.

This will complete the job of obtaining the fatigue life distribution most representative of the data for the given two-parameter failure model.

a. Point Estimate of Weibull Characteristic Life

As given in Sec. IV [Eq. (IV-17)], the MLE of β, with $\alpha = 1/\kappa$ known, is

$$\hat{\beta} = \left[\frac{1}{n_f}\left(\sum_{i=1}^{n_f} Y_i^\alpha + \sum_{i=1}^{n_g} G_i^\alpha\right)\right]^{1/\alpha} \qquad \text{(V-1)}$$

This estimate is workable, in the sense that its important properties are known, only for those small samples that are complete or censored by failure time. Considering the case of single-stage censoring at the $n_f{}^{th}$ failure time only, Eq. (V-1) becomes

$$\hat{\beta} = \hat{\beta} = \left[\frac{1}{n_f}\left(\sum_{i=1}^{n_f} Y_i^\alpha + (n-n_f)\ Y_{(n_f)}^\alpha\right)\right]^{1/\alpha} \qquad \text{(V-2)}$$

Equation (V-2) gives an unbiased[3] uniformly minimum variance estimator for which the sampling distribution is known.

b. Point Estimate of Log-Normal Median Life

For small samples ($n_f \leq 50$), only the case of uncensored samples will be considered here. The relevant MLE is simply the data log-average

$$\hat{U} = \hat{U} = \frac{1}{n} \sum_{i=1}^{n} \log Y_i \qquad \text{(V-3)}$$

This scale parameter estimator is free of bias and possesses minimum variance of expected loss (mean-squared error).

---

[3] Actually $E(\hat{\beta}) = \beta$ and $E(\hat{\beta}^\alpha) = \beta^\alpha$

c. Point Estimate of Single Parameter: Tchebycheff Inequality

For this case of no assumed failure model, we will choose to estimate the average of logarithmic failure times $\bar{n} = \overline{\log Y}$. This is consistent with the arbitrary use of $\sigma = 0.14$ as the known value of the standard deviation of logarithms. The arbitrariness arises from the fact that this particular value was influenced by previous assumptions of log normality and here we are applying it as a "known" quantity in a distribution-free limit theorem.

4. LOWER BOUND INTERVAL ESTIMATE OF FATIGUE-LIFE DISTRIBUTION

It is in this step that knowledge of the scatter-controlling shape parameter yields the greatest dividends. For one thing, the analysis is greatly simplified; but far more importantly, the lack of a sampling of many full-scale structural fatigue life observations becomes a small rather than an insurmountable problem. The sampling distributions of the Weibull $\hat{\beta}$ and log-normal $\hat{\eta}$ estimators are given below in terms of a probability statement of confidence level and in terms of a scatter factor S_{n_f}, accounting for finite sample size alone. The same task is done with the data log-average estimator $\bar{n}$, using distribution-free methods.

a. Exact Lower Confidence Bounds for Weibull Scale Parameter

Appendix I contains the proof of a theorem important for our applications; namely, that the statistic $2n_f\ W = 2n_f\ (\beta/\hat{\beta})^{\alpha}$ has the chi-squared distribution with $2n_f$ degrees of freedom. It is therefore possible to express an interval estimate of β as

$$\check{\beta}_{\gamma} = \hat{\beta}\left[\frac{1}{2n_f}\ \chi^2_{\gamma}\ (2n_f)\right]^{-1/\alpha} \qquad \text{(V-4)}$$

where $\chi^2_{\gamma}\ (2n_f)$ is the γ-fractile of the chi-squared variate with $2n_f$ degrees of freedom and where β_{γ} satisfies

$$P(\check{\beta}_{\gamma} \leq \beta) = \gamma$$

The scatter factor S_{n_f} can then be defined that shows the penalty paid to gain confidence γ from a finite sample size. This factor is expressed as

$$S_{n_f} = \frac{\hat{\beta}}{\check{\beta}_{\gamma}} = \left[\frac{1}{2n_f}\chi^2_{\gamma}\ \ (2n_f)\right]^{1/\alpha} \qquad \text{(V-5)}$$

b. Exact Lower Confidence Bounds for Log-Normal Scale Parameter

One of the most widely used statistics is $\frac{\hat{\mu}-\mu}{\sigma/\sqrt{n}}$, which, for the case of complete samples, has standard normal distribution. It is therefore possible to obtain an exact lower bound of μ as

$$\check{\mu}_\gamma = \hat{\mu} + k_\gamma \frac{\sigma}{\sqrt{n}} \tag{V-6}$$

where the standard normal deviate k_γ is a negative number when γ is greater than 0.5.

Equation (V-6) leads directly to the statement of confidence

$$P\ (\check{\mu}_\gamma \le \mu) = \gamma \tag{V-7}$$

since from properties of the normal distribution we can say

$$P\ (\check{\mu} \ge \hat{\mu} + k_\gamma\ \sigma/\sqrt{n}\ ) = \gamma \tag{V-8}$$

Since $\check{\mu}_\gamma$ and μ are in terms of log life, we define S_n as

$$S_n = 10^{(\mu-\check{\mu}_\gamma)} = 10^{-k_\gamma \frac{\sigma}{\sqrt{n}}} \tag{V-9}$$

c. Precise Confidence Bounds, No Distribution Assumed

If absolutely nothing is known or assumed about the distribution of fatigue lives except the value of its (logarithmic) variance, one (weak) tool that may be applied to bound η is the distribution-free Tchebycheff inequality. If the variance of log lives is σ^2, the variance of $\bar{\eta}$ is known to be σ^2/n, regardless of the distribution. We may then write, for any number, $\delta \ge 1$,

$$P(|\bar{\eta} - \eta| \le \delta\frac{\sigma}{\sqrt{n}}\ ) \ge 1 - \frac{1}{\delta^2} = \gamma \tag{V-10}$$

This allows the construction of a lower bound, $\check{\eta}_\gamma$, given by

$$\check{\eta}_\gamma = \bar{\eta} - \frac{\sigma}{\sqrt{n\ (1-\gamma)}} \tag{V-11}$$

which satisfies

$$P(\check{\eta}_\gamma \le \eta) \ge \gamma \tag{V-12}$$

We can evaluate the scatter factor by means of Eq. (V-11) as

$$S_n = 10^{(\hat{n} - \check{n}_\gamma)} = 10^{\left(\frac{\sigma}{\sqrt{n(1-\gamma)}}\right)} \quad \text{(V-13)}$$

5. FACTORS FOR LOWER BOUND ESTIMATE OF A CERTIFIABLE LIFE

At this stage, the final part of the analysis, all estimation work has been concluded. In all that follows, the lower bound interval estimate $\check{F}_\gamma(y)$ is treated mathematically as if it were the true fatigue-life distribution $F(y)$. Of course, the resultant safe-life calculation is only an estimate at the same chosen level of confidence γ.

It is assumed here that the following specification, recommended in Sec. II, is made by customer and/or vendor management for a particular component.

> With probability $\bar{R}$, the safe life that is being estimated at confidence level γ shall be exceeded by at least $N-M+1$ of the N exposed structural components.

The first task is to transform $\bar{F} = 1-\bar{R}$, the failure probability of the weakest of N identical components, into an equivalent value of F, the failure probability of any randomly selected component. This may be done precisely through the cumulative binomial formula, whose derivation appears in Ref. 28.

The probability of exactly M failures and the probability of at least M failures (equal to the failure probability of the "M^{th} weakest" member) are given, respectively, by

$$P(T = M) = \binom{N}{M} F^M (1-F)^{N-M} \quad \text{(V-14)}$$

$$P(T \geq M) = \sum_{i=M}^{N} \binom{N}{i} F^i (1-F)^{N-i} \quad \text{(V-15)}$$

A form of Eq. (V-15) that is easy to calculate for small values of M and large N is

$$P(T \geq M) = \bar{F}_{M;N} = \bar{F} = 1 - \sum_{i=0}^{M-1} \binom{N}{i} F^i (1-F)^{N-i} \quad \text{(V-16)}$$

This equation, as mentioned before, was plotted for several values of M and N in Fig. 3.

Strictly speaking, Eq. (V-16) is not the cumulative binomial distribution as implied but simply one minus same. It can always be used to calculate the "general" reliability, associated with a random fleet member, that corresponds to the specified reliability for the M^{th} failure among N members for all integer values; thus,

$$1 \le M \le N \cdot \infty$$

However, since the design parameter advocated is usually associated with the first- or second-order statistic, attention may be restricted to the special cases:

(1) $M = 1, N \geq 1$
where Eq. (V-16) reduces to

$$\bar{F} = \bar{F}_{1;N} = 1-(1-F)^N \qquad \text{(V-17)}$$

or, in terms of reliabilities, to

$$\bar{R} = R^N \qquad \text{(V-18)}$$

(2) $M = 2, N \geq 2$
where Eq. (V-16) reduces to

$$\bar{F} = \bar{F}_{2;N} = 1-(1-F)^N - NF(1-F)^{N-1} \qquad \text{(V-19)}$$

or, in terms of reliabilities, to

$$\bar{R} = NR^{N-1} \left| 1-R \left(\frac{N-1}{N}\right) \right| \qquad \text{(V-20)}$$

a. **Estimate of Safe Life: Weibull Model**

As shown previously, the lower bound interval estimate of reliability R as a function of component age y is given by

$$\breve{R}\,(y) = 1-\breve{F}\,(y) = \exp\left|-(y/\breve{\beta})^{\alpha}\right| \qquad \text{(V-21)}$$

Assume now that the minimum acceptable value of R has been calculated, as a function of specified values of M, N, and $\bar{R}$, by means of Eq. (V-16). Then we need only solve for y in Eq. (V-21) to obtain the "inverse reliability function" and, therefore, the safe life

$$\breve{Y}_R = \breve{Y}(R) = \breve{\beta}\left[\ln\,(1/R)\right]^{1/\alpha} \qquad \text{(V-22)}$$

The scatter factor accounting for both the fleet exposure and the specified fleet reliability $\bar{R}$ is simply

$$S_R = \frac{\breve{\beta}}{\breve{Y}_R} = \left|\ln\,(1/R)\right|^{-1/\alpha} \qquad \text{(V-23)}$$

For the case where the entire fleet (weakest member) is being protected, we have $M = 1$ and

$$R = \bar{\bar{R}}^{\,1/N}$$

So that safe life and scatter factor are given, respectively, by

$$\check{Y}_R = \left[\frac{1}{N}\ \ell n\ (1/\bar{\bar{R}})\right]^{1/\alpha} \qquad \text{(V-24)}$$

and

$$S_R = \left[\frac{1}{N}\ \ell n\ (1/\bar{\bar{R}})\right]^{-1/\alpha} \qquad \text{(V-25)}$$

For this case, the safe life and the total scatter factor S can be written as

$$\check{Y}_R = \check{Z}_{\bar{\bar{R}}} = \hat{\beta}\left[\frac{2n_f}{N}\ \frac{\ell n(1/\bar{\bar{R}})}{\chi_\gamma^2(2n_f)}\right]^{1/\alpha} \qquad \text{(V-26)}$$

and

$$S = S_{n_f} \cdot S_R = \frac{\hat{\beta}}{\check{Y}_R} = \left[\frac{N}{2n_f}\ \frac{\chi_\gamma^2\ (2n_f)}{\ell n\ (1/\bar{\bar{R}})}\right]^{1/\alpha} \qquad \text{(V-27)}$$

b. Estimate of Safe Life: Log-Normal Model

The development for the case of the reliability being specified in terms of the time to first failure is no more difficult for this model than for the Weibull model. The resultant safe life and scatter factors are listed below:

$$\check{Y}_R = 10^{[\check{\mu} + k_R\sigma]} = 10^{\left[\hat{\mu} + \left(\frac{k_\gamma}{\sqrt{n}} + k_R\right)\sigma\right]} \qquad \text{(V-28)}$$

$$S_R = \frac{10^{\check{\mu}}}{\check{Y}_R} = 10^{-k_R\sigma} \qquad \text{(V-29)}$$

$$S = S_n \cdot S_R = \frac{10^{\hat{\mu}}}{\check{Y}_R} = 10^{-\left(\frac{k_\gamma}{\sqrt{n}} + k_R\right)\sigma} \qquad \text{(V-30)}$$

where $R = \bar{\bar{R}}^{\,1/N}$.

c. Estimate of Safe Life: No Model

We again make use of the generally applicable Tchebycheff limit theorem to establish the reliability function for this case as

$$R(y) \geq 1 - \frac{\sigma^2}{(\bar{\eta} - \log y)^2}, \quad \log y < \eta - \sigma \qquad \text{(V-31)}$$

and for known σ.

The safe-life and scatter-factor equations can then be derived as

$$\check{Y}_R = 10^{\left(\check{\eta} - \frac{\sigma}{\sqrt{1-\bar{R}^{1/N}}}\right)} \qquad \text{(V-32)}$$

or

$$\check{Y}_R = 10^{\left[\bar{\eta} - \left(\frac{1}{\sqrt{n\,(1-\gamma)}} + \frac{1}{\sqrt{1 - \bar{R}^{1/N}}}\right)\sigma\right]} \qquad \text{(V-33)}$$

and

$$S_R = \frac{10^{\check{\eta}}}{\check{Y}_R} = 10^{\left[\frac{\sigma}{\sqrt{1 - \bar{R}^{1/N}}}\right]} \qquad \text{(V-34)}$$

and, therefore, the total scatter factor is

$$S = S_n \cdot S_R = \frac{10^{\bar{\eta}}}{\check{Y}_R} = 10^{\sigma\left[\frac{1}{\sqrt{n\,(1-\gamma)}} + \frac{1}{\sqrt{1 - \bar{R}^{1/N}}}\right]} \qquad \text{(V-35)}$$

To facilitate numerical comparisons and safe-life computations, scatter factors corresponding to various values of all relevant parameters were computed and presented in Tables IX, X, XIII, XIV, and XV and in Fig. 45 through 50. In the tabulations it was arbitrarily decided to subdivide S_R into two factors, $S_{\bar{R}}$ and $S_{N_{\bar{R}}}$, such that for fixed M,

$$S_R = S_{\bar{R}} \cdot S_{N_{\bar{R}}}$$

This was done to enable a comparison of the factor $S_{\bar{R}}$ required for reliability in just a one-member fleet and of the factor $S_{N_{\bar{R}}}$ required to account for the size N of the exposed fleet. The factor $S_{N_{\bar{R}}}$, as can be inferred from the double subscripts, depends on $\bar{R}$ as well as on N. This condition arises because the order statistic's distribution is usually of a different form than the parent distribution,

so that one simple factor (scalar translation) cannot be used to compute all fractiles of the order statistic's distribution. One exception to this is the Weibull model for M = 1, where the distribution of times to first failure is also Weibull with the same shape as the parent. In this case we take the liberty of changing the notation $S_{N\bar{R}}$ to S_N to symbolize the lack of dependence of S_N upon $\bar{R}$.

The parametric study of these scatter factors brought out several expected trends. The log-normal model, with low failure rates or mortality at old age, predicts more chance for a long-lived test specimen and, therefore, higher values of S_{n_f}. The Weibull model, with monotonically and rapidly increasing failure rate, leads to scatter factors $S_{N\bar{R}}$ and $S_{\bar{R}}$ higher than those of the log-normal model, especially when the fleet is large or the specified reliability is high. Therefore, for the typically large (N>100) fleets of aircraft in operation, the Weibull model would lead to a higher total scatter factor S and a lower safe-life estimate than the log-normal would for a given specification.

SECTION VI

CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS

A study of the available options for formulating a reliability plan based on the collected aluminum fatigue test data has induced the following conclusions:

a) The most feasible method of using the Weibull, or log-normal, time-to-failure model as a basis for aircraft reliability assessment is to first calculate and fix shape-parameter values from a large mass of applicable fatigue data and then to base all subsequent analytical work on these "known" values.

b) Considering that the applicable fatigue performance data comprised samples from:

- all the investigated aluminum alloys, which contained both the major 2000- and 7000-series alloys;
- all the notched configurations, including simple monolithic notched, the less simple structural simulators such as laboratory-type lap joints, butt joints, etc., and the full-scale structural components and structures;
- axially loaded and flexurally loaded test programs;
- constant-amplitude and variable-amplitude testing procedures; and
- a fatigue-life range between 10^2 and 10^6 cycles,

it was demonstrated that the estimated shape parameter was not influenced by:

1) material alloy type
2) specimen geometry
3) fatigue test machine
4) test loading procedure
5) cyclic life

c) Considering the very general conditions listed in conclusion b, it is believed that for most aluminum structural applications a reasonable value of the Weibull shape parameter is $\alpha = 4.0$ and for the log-normal case $\sigma = 0.14$.

d) Fatigue scatter is greater for the following:

1) rotating beam tests
2) hand forgings
3) compression testing
4) adhesively bonded joints
5) low-amplitude/high-life testing

e) Fatigue scatter is lower for the following:

1) unnotched specimens
2) ultracarefully manufactured test specimens

f) Currently the two-ordered-statistic estimator $\tilde{\kappa}$ is the preferred estimator for the task of determining the Weibull shape parameter α from fatigue data, because:

1) $\tilde{\kappa}$ is simple to calculate, as no iterative-type solutions are necessary;

2) the idea of emphasizing the lowest failure times in each data group to calculate fatigue scatter is consistent with the concept of specifying safe life as a fractile of the distribution of the lowest failure time in the fleet;
3) an estimation procedure that considers only the lowest two failure times must be nearly insensitive to the occurrence of hightime outliers that are not predicted by the failure time model; and
4) it was demonstrated that a fairly close agreement exists between the observed and theoretical sampling distributions of $\tilde{k}$, which lends credence to the belief that the fatigue performance of the weaker members of a sample or a fleet may be adequately described by the Weibull model.

g) In the majority of cases, the use of the Weibull distribution model will lead to a lower estimate of safe life than that determined from the log-normal model.

h) The Weibull distribution is characterized by a failure rate that increases monotonically and rapidly; consequently, the calculated Weibull scatter factors are largely dependent on specified (high) reliability and fleet exposure.

i) The log-normal distribution, by reason of a failure rate that eventually decreases to zero, predicts more chance for possible high-time test failures than does the Weibull model. The calculated log-normal scatter factors reflect this and demonstrate greater dependence on fatigue test sample size than the corresponding Weibull values.

j) The results from a reliability analysis based on either of the considered distribution models relative to the current approach to safe-life estimation (i.e. the arbitrary scatter factor of 4) shows that the latter approach may result in a very low degree of reliability of the weakest members of the fleet, and this is emphasized by the large size of some of the current operational fleets.

k) The initial results of the reliability analysis demonstrate some promise of correlation between service and predicted fatigue performance.

l) The application of the proposed analysis could result in an improvement in fatigue reliability at the cost of some increase in structural weight, with subsequent loss in payload or range.

Having demonstrated the applicability of the reliability plan, the following recommendations can be made.

2. RECOMMENDATIONS

a) The analysis should be extended to cover some other common aircraft materials, such as titanium and high-strength steel.

b) The Monte-Carlo studies should be continued to complete the listing of bias and variance values for shape-parameter estimates from censored samples of small size for inclusion into the computer program to provide the capability of assimilating these data into the overall weighted estimate.

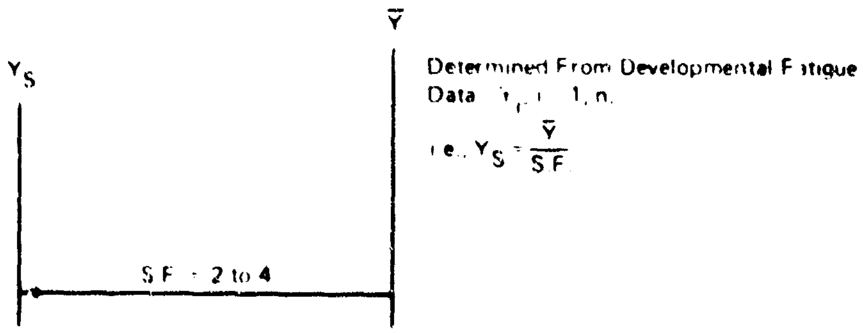
c) Other distribution functions should be considered, especially those of a fairly general nature but not necessarily as indefinite as the Tchebycheff limit theorem or other distribution-free assumptions.

It is expected that the collected fatigue data could be used as a guideline toward selection of representative models.

d) The possibility of devising and applying a two-ordered-statistic estimator for the shape parameters of the log-normal and other time-to-failure models should be investigated.

e) The results of this study should be incorporated into previously explored failure models that combine the chance static and fatigue modes of failure.

CURRENT APPROACH SCATTER FACTOR METHOD

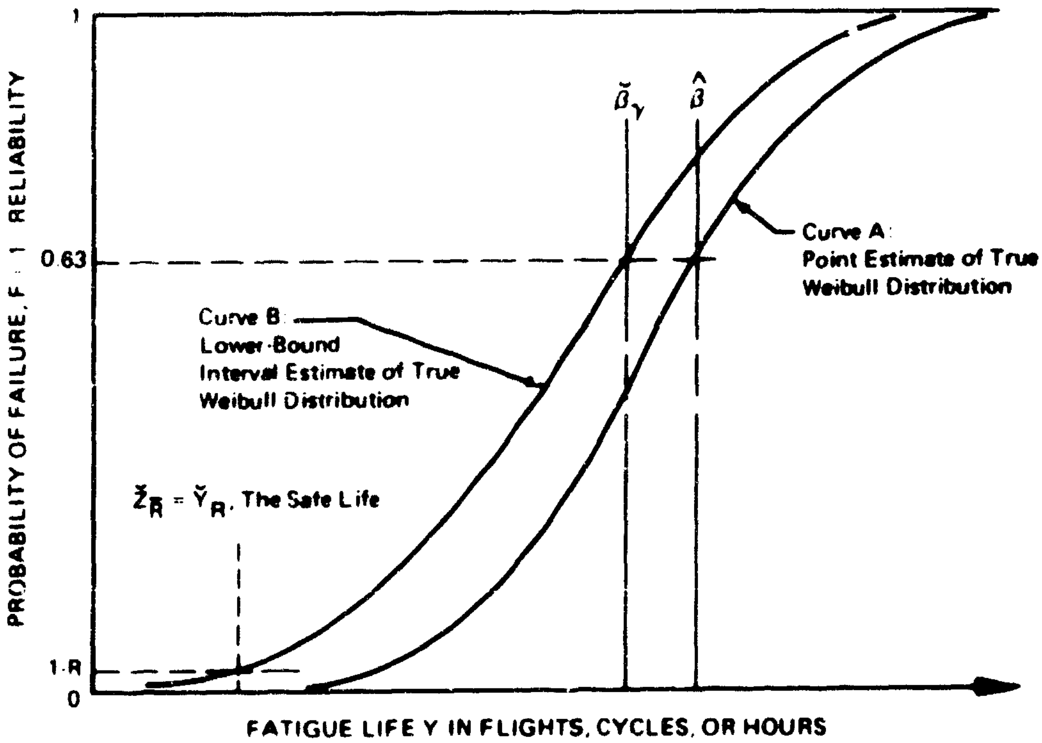


NOTE The design life is taken to be Y_S, the inference seems to be that $P(Y > Y_S)$ is acceptable although undefined.

Figure 1 Schematic Representation of Current Reliability Plan

PROCEDURE

1. Assume fatigue life is a random variable with a two-parameter Weibull distribution.
2. Estimate the shape parameter α from all applicable data and regard it as fixed in all that follows.
3. Estimate the scale parameter β from full-scale fatigue test(s), thereby defining Curve A.
4. Using the small full-scale test sample only, obtain a lower interval estimate $\breve{\beta}_\gamma$ of β, thereby defining Curve B at the confidence level γ.
5. Specify or compute a desired reliability R of an arbitrary fleet member. Use Curve B to obtain the corresponding certifiable life $\breve{Y}_R$.



<u>Specification of Desired Reliability</u>

The value of R, the minimum allowable reliability of a randomly chosen fleet member, may be arbitrarily speci[illegible]r may be based on and calculated precisely from a specification of the reliab[illegible]ty $\bar{R}$ of the M^{th} weakest of N fleet members.

Figure 2. Outline and Schematic Representation of Proposed Reliability Plan

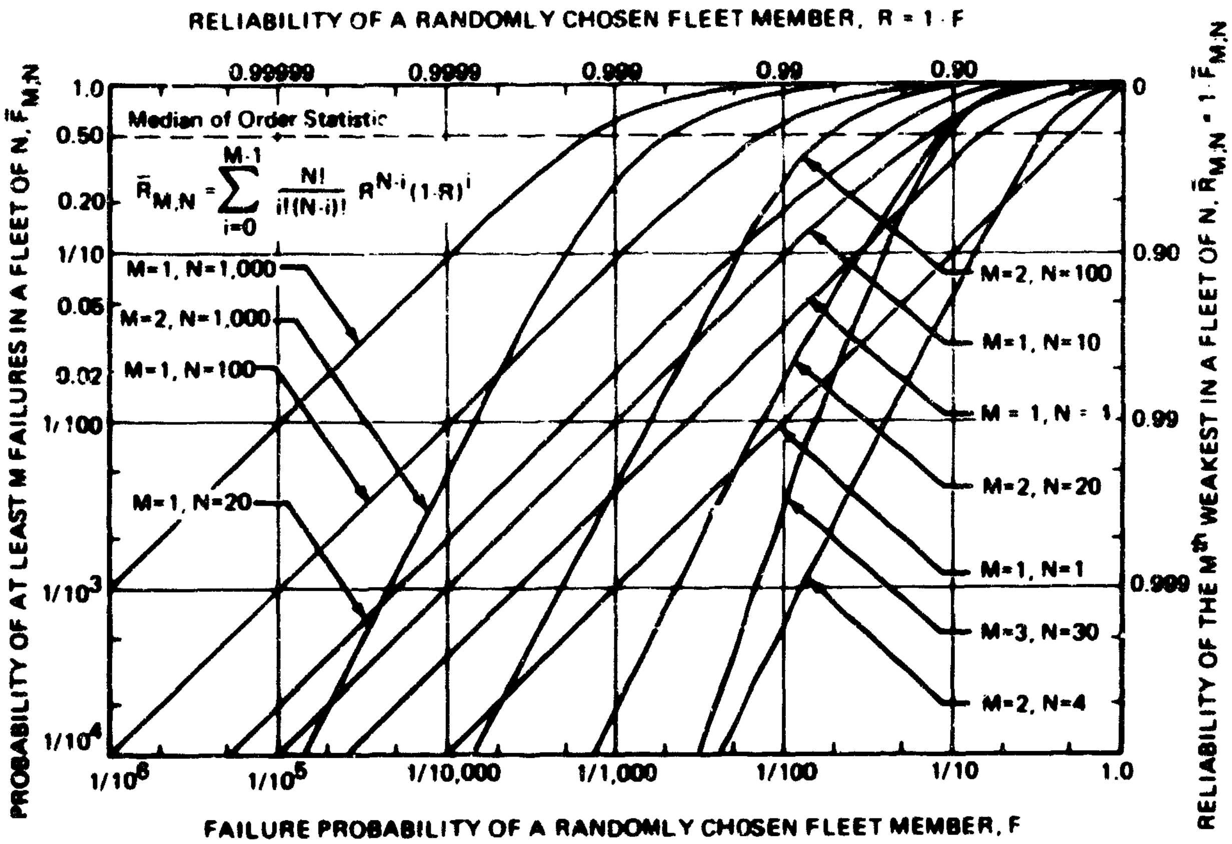


Figure 3. Distribution of Several Order Statistics

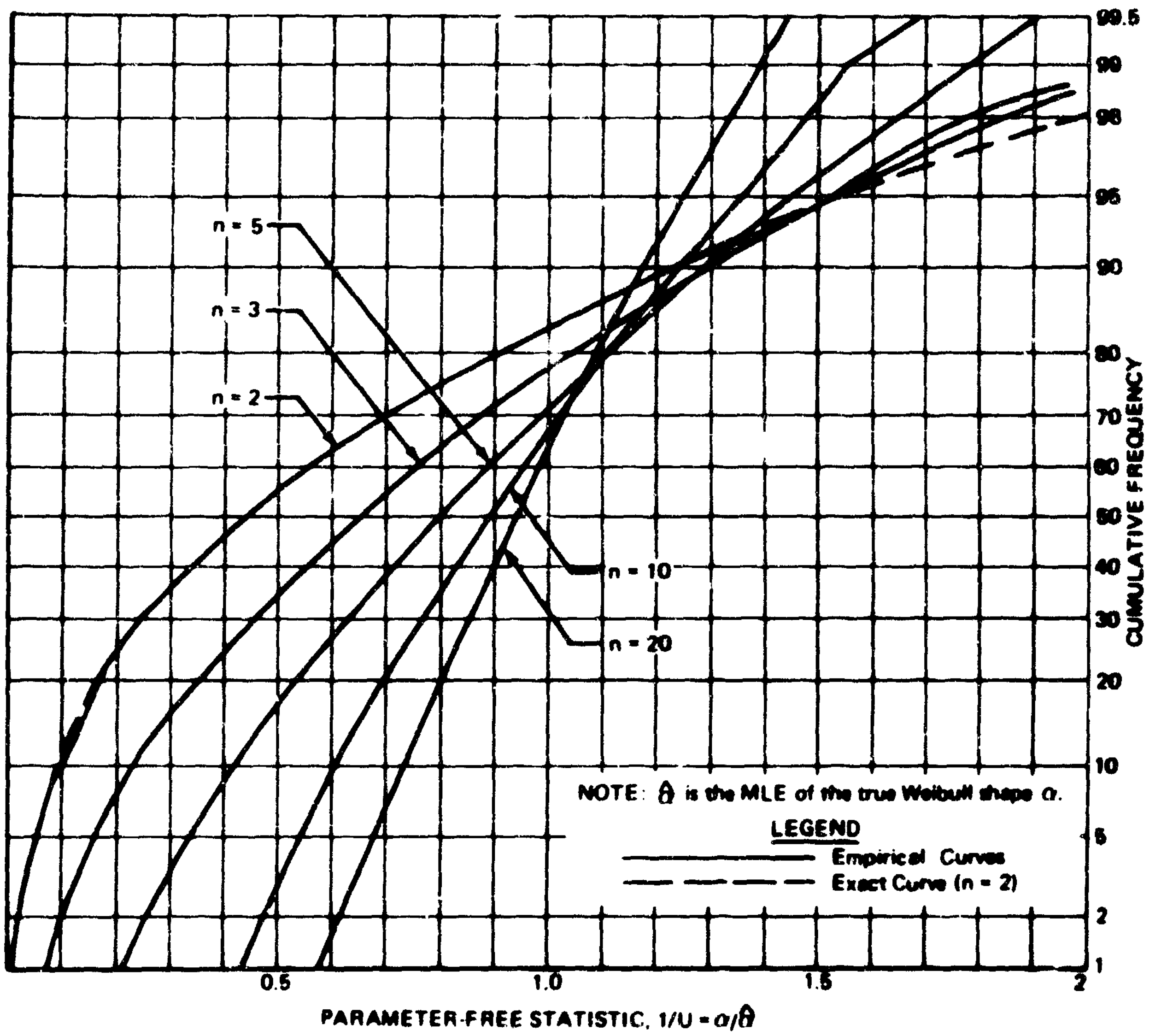


Figure 4. Empirical Distribution of the MLE of the Weibull Shape Parameter α for Complete Samples

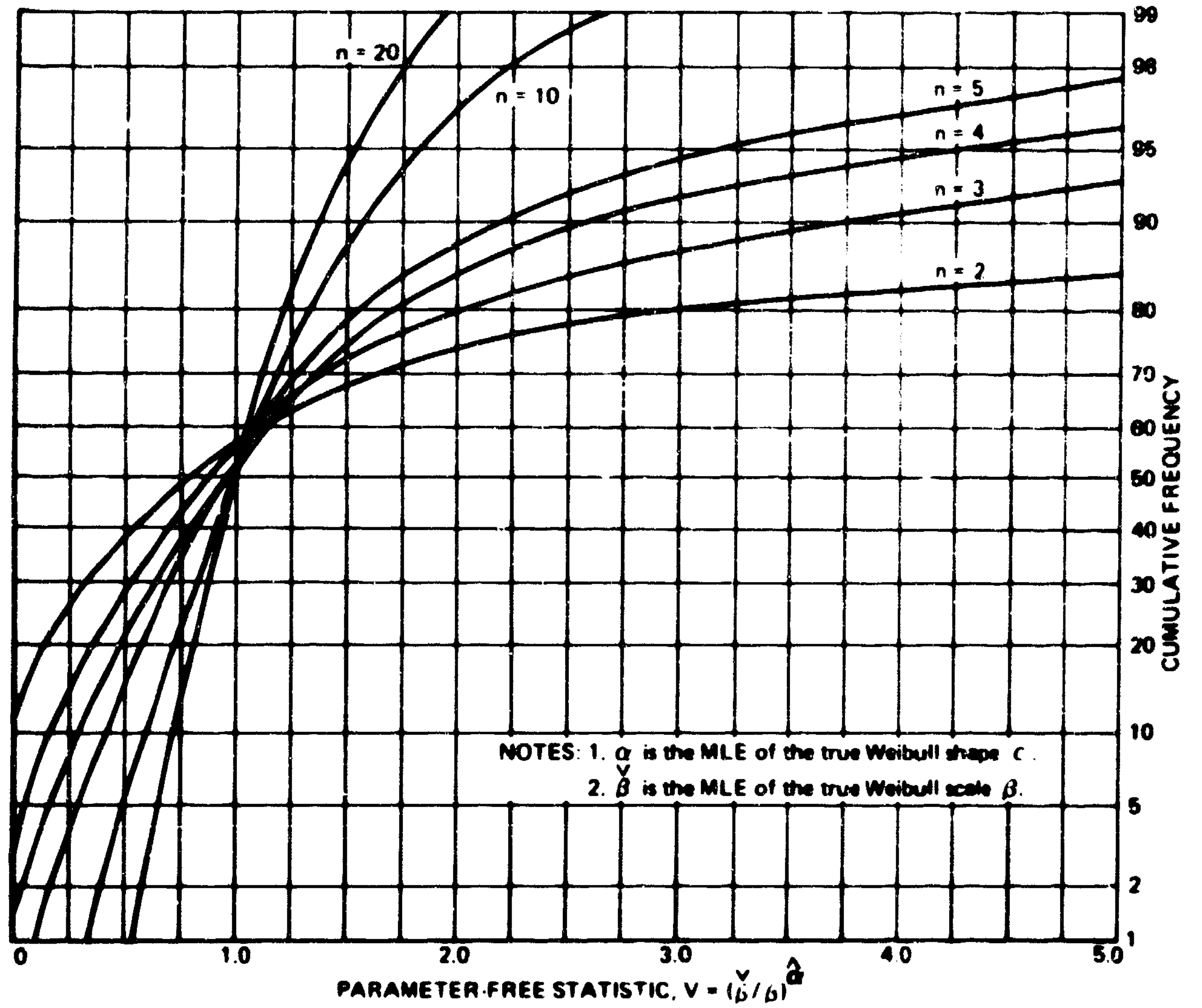


Figure 5. Empirical Distribution of the MLE of the Weibull Scale Parameter β for Complete Samples of Size $n = m = 2, 3, 4, 5, 10$, and 20 (Weibull Shape Assumed To Be Unknown)

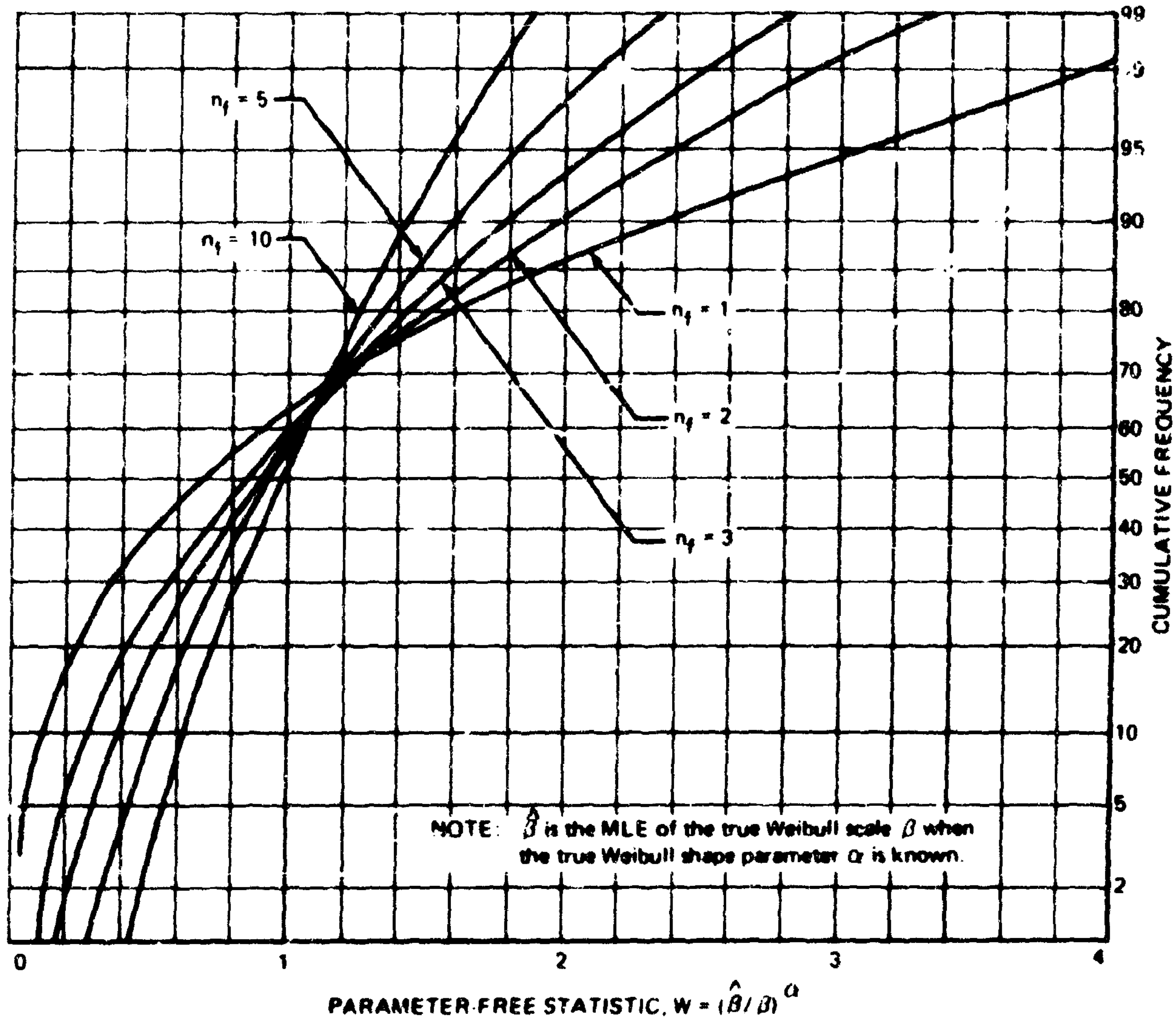


Figure 6. Theoretical Distribution of the MLE of the Weibull Scale Parameter β for Complete Samples (Weibull Shape Assumed To Be Known)

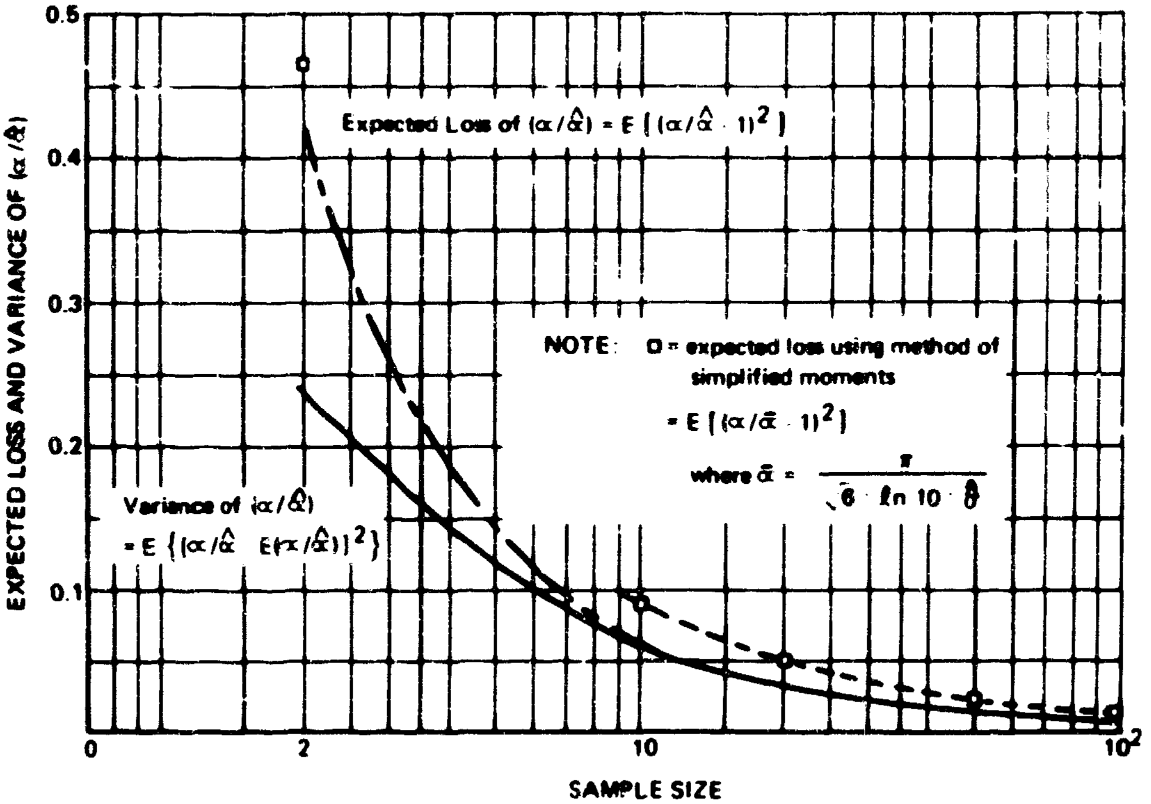


Figure 7. A Measure of Sampling Error of the MLE of the Weibull Shape From Complete Samples

ALUMINUM FATIGUE TEST DATA: TOTAL OF EXAMINED DATA

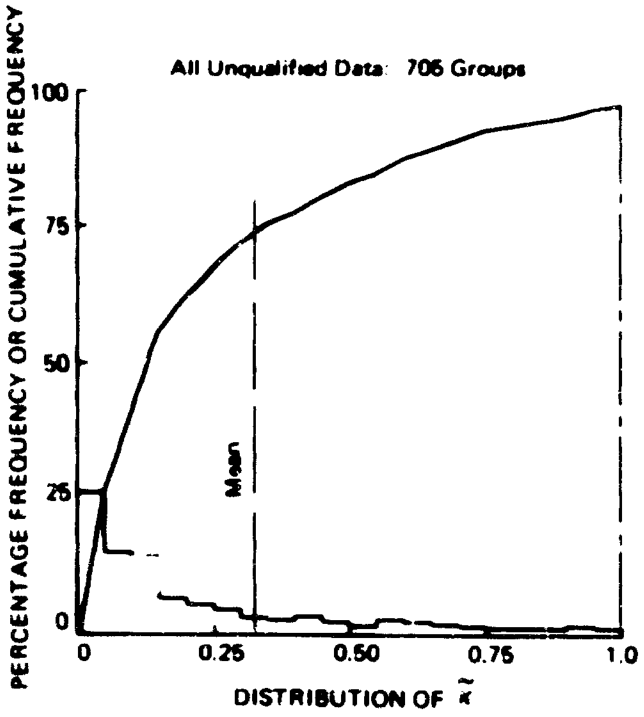


Figure 8. Distribution of Observed Estimates of the Weibull Shape Parameter for All Unqualified Data

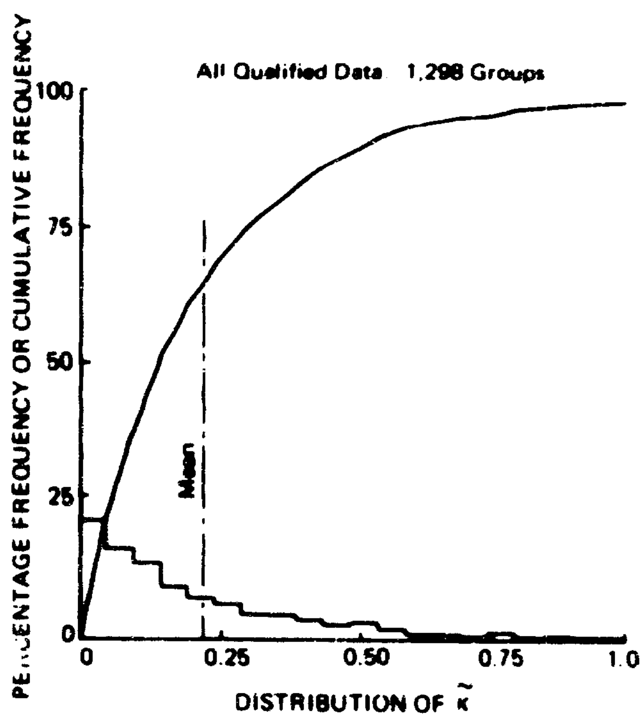


Figure 9. Distribution of Observed Estimates of the Weibull Shape Parameter for All Qualified Data

ALUMINUM FATIGUE TEST DATA

(Limited to simple notched, joints, and structures, excluding low-amplitude, high-cycle data)

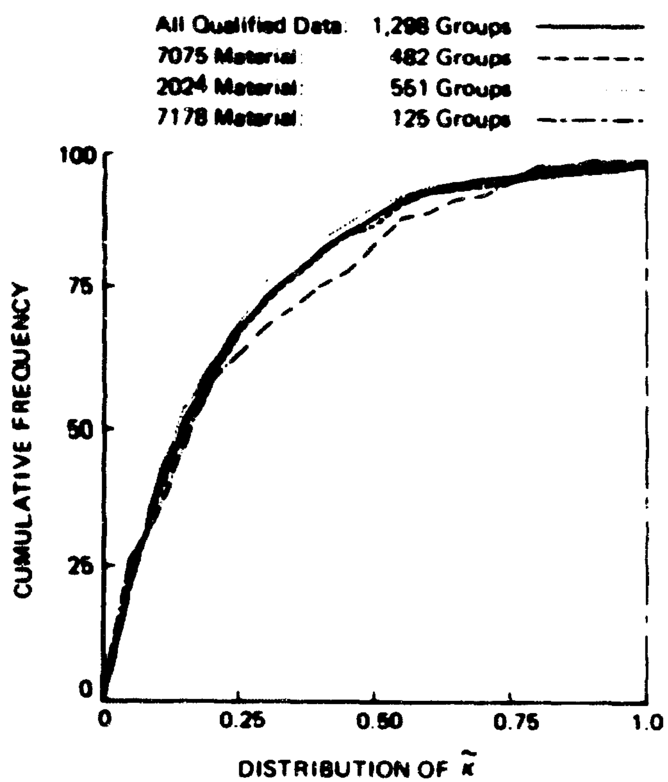


Figure 10. *Comparison of the Distribution of Observed Estimates of the Weibull Shape Parameter for Several Alloys*

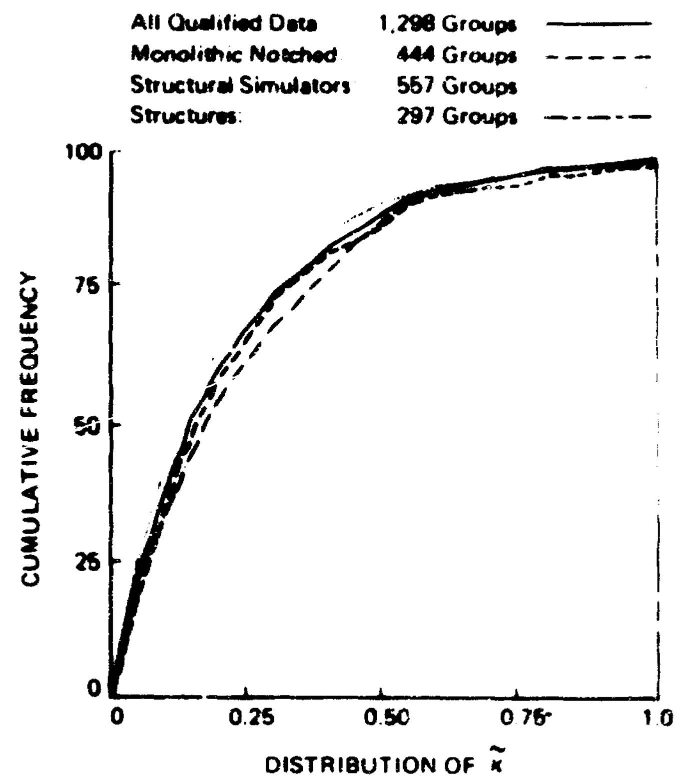


Figure 11. *Comparison of the Distribution of Observed Estimates of the Weibull Shape Parameter for Several Specimen Types*

ALUMINUM FATIGUE TEST DATA

(Limited to simple notched, joints, and structures, excluding low-amplitude, high-cycle data)

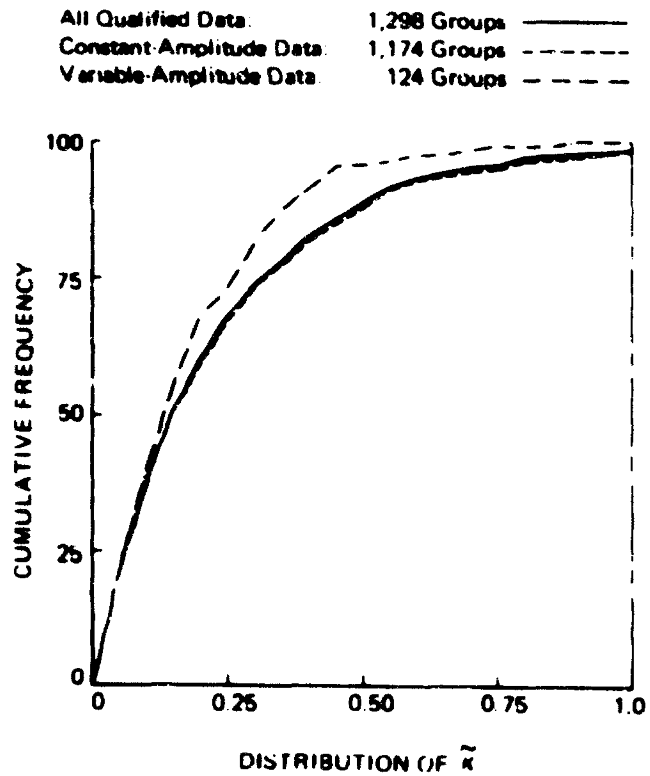


Figure 12. Comparison of the Distribution of Observed Estimates of the Weibull Shape Parameter for Different Types of Loading

(Sample categories of rejected data)

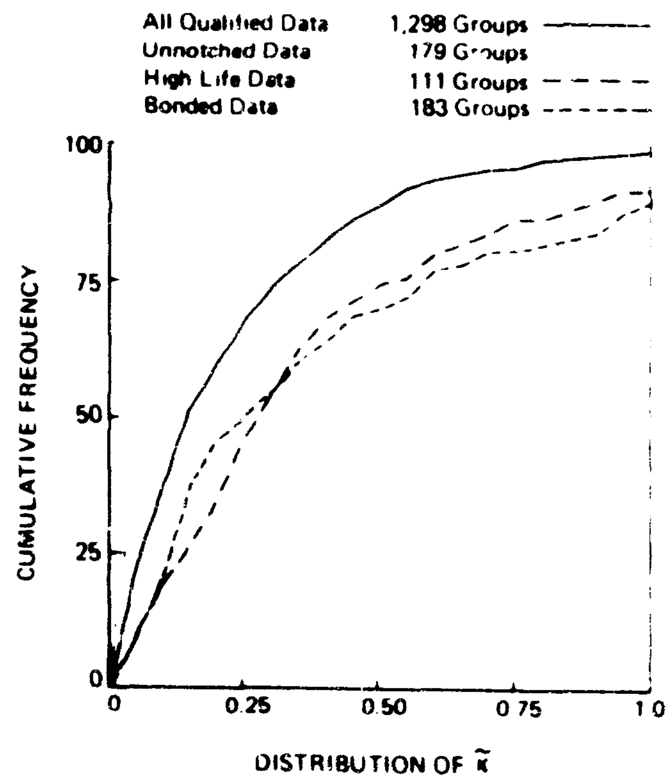


Figure 13. Comparison of the Distribution of Observed Estimates of the Weibull Shape Parameter for Various Unacceptable Data

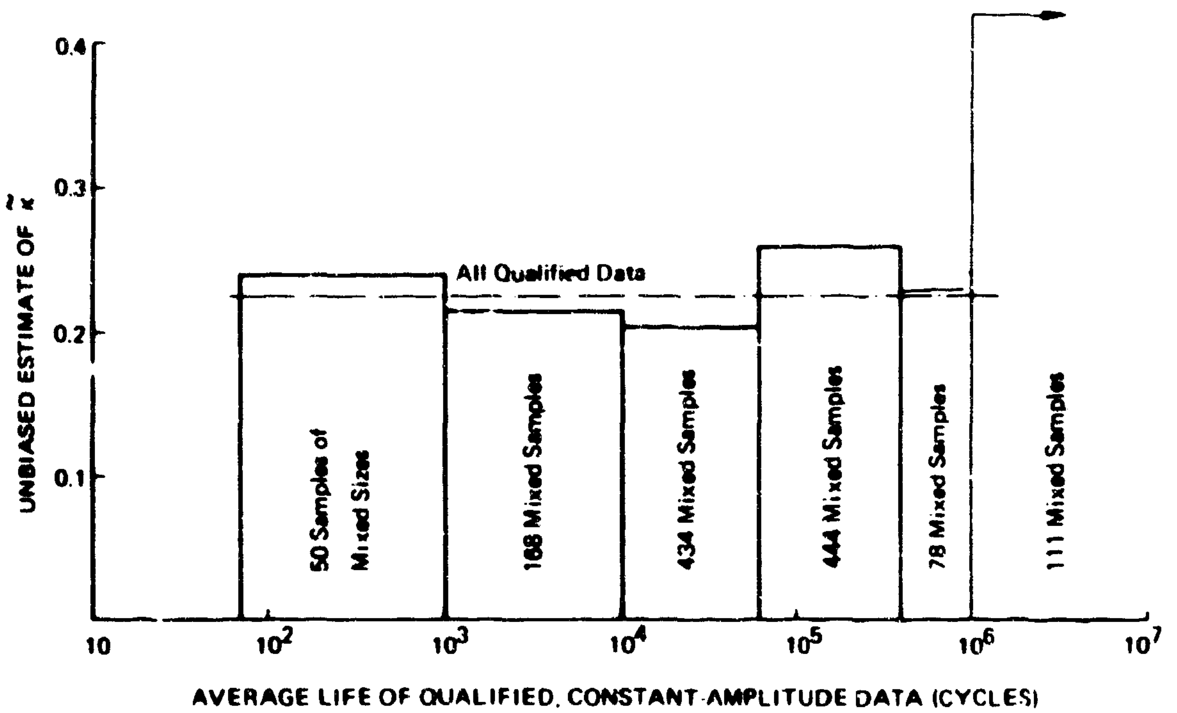


Figure 14. Observed Variation of Fatigue Scatter With Cyclic Life for 1,174 Constant-Amplitude Samples of Mixed Sizes

ALUMINUM FATIGUE TEST DATA

(Limited to simple notched, joints, and structures, excluding low-amplitude, high-cycle data)

Test Data Distribution

Theoretical Distribution: $\kappa = \tilde{\kappa}' = 0.224$

Theoretical Distribution: $\kappa = \tilde{\kappa}'_{0.96} = 0.253$

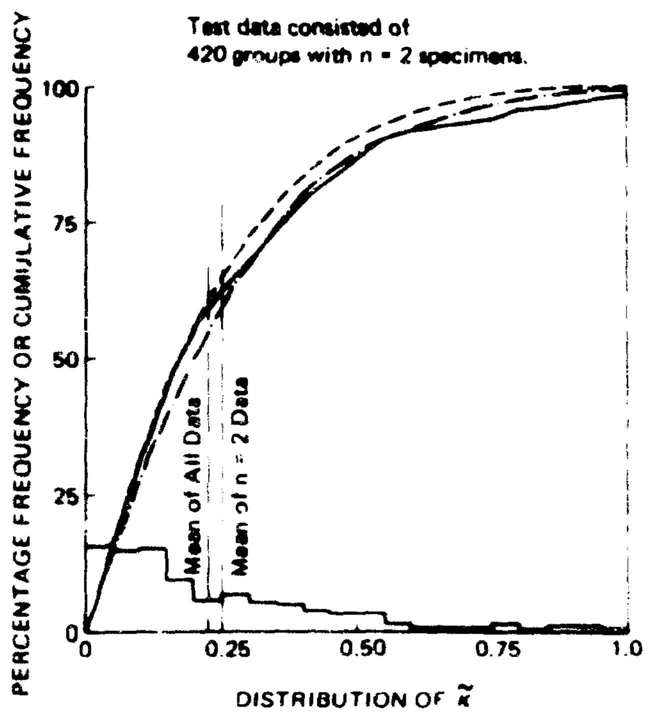


Figure 15. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter for Only Qualified Data of Sample Size = 2

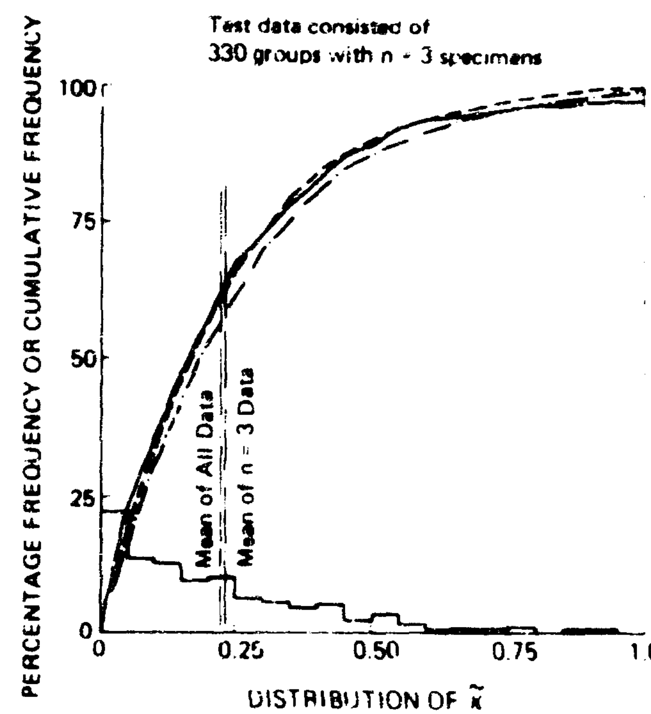


Figure 16. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter, Using First Two Ordered Failures of Only Qualified Data of Sample Size = 3

ALUMINUM FATIGUE TEST DATA

(Limited to simple notched, joints, and structures, excluding low amplitude high cycle data)

Test Data Distribution

Theoretical Distribution $\kappa = \bar{\tilde{\kappa}} = 0.224$ - - - - - -

Theoretical Distribution $\kappa = \tilde{\kappa}_{0.95} = 0.253$ — — —

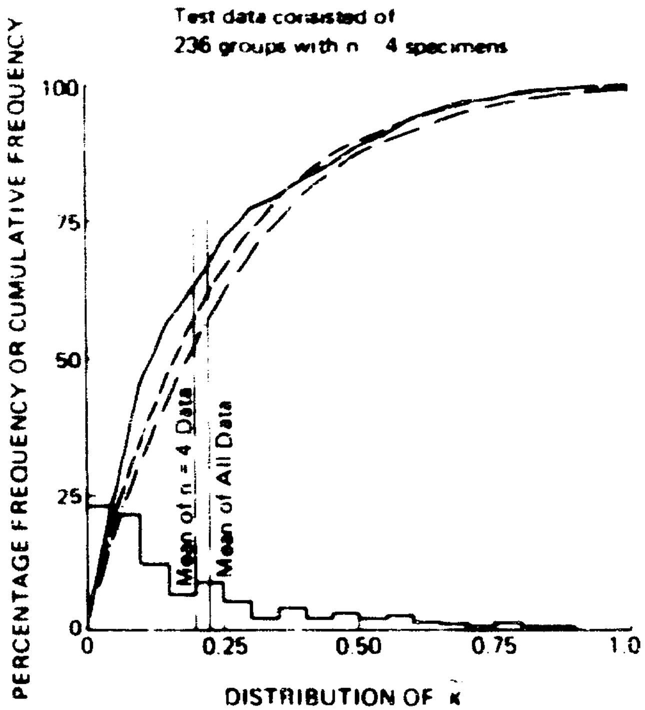


Figure 17. *Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter, Using First Two-Ordered Failures of Only Qualified Data of Sample Size = 4*

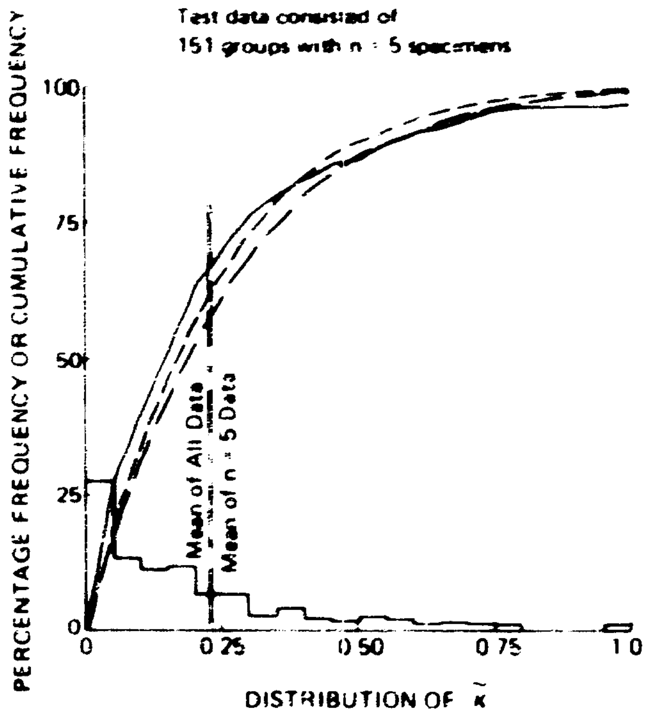


Figure 18. *Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter, Using First Two-Ordered Failures of Only Qualified Data of Sample Size = 5*

ALUMINUM FATIGUE TEST DATA   TOTAL OF EXAMINED DATA

Test Data Distribution ————
Theoretical Distribution - - - - - -

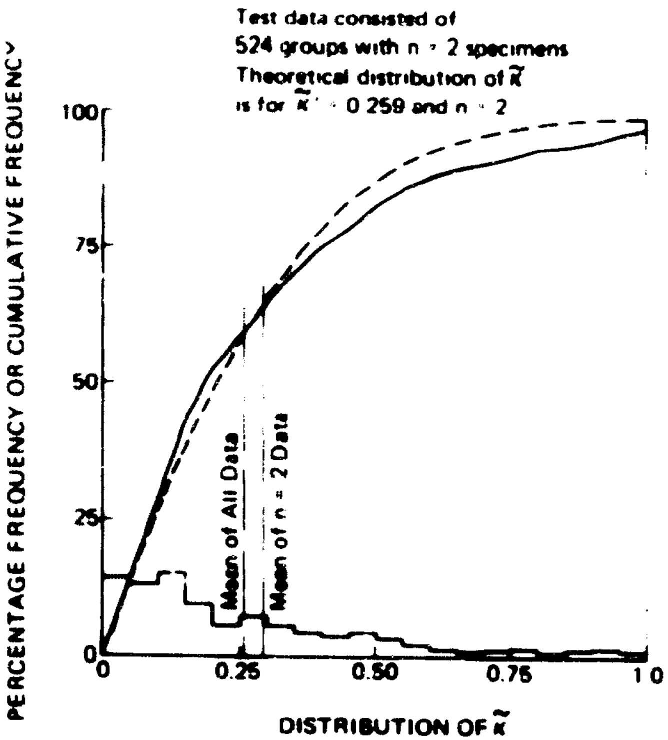


Figure 19. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter for All Collected Data of Sample Size = 2

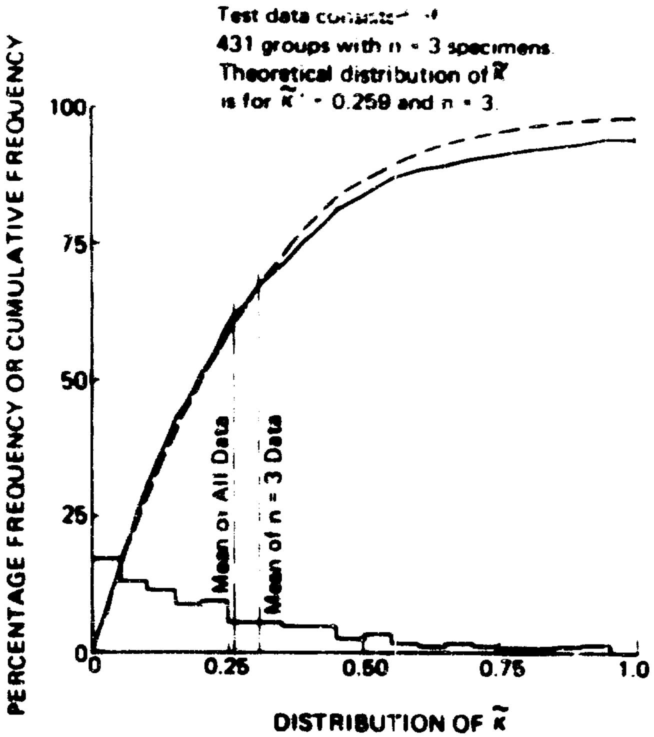


Figure 20. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter, Using First Two-Ordered Failures of All Collected Data of Sample Size = 3

ALUMINUM FATIGUE TEST DATA: TOTAL OF EXAMINED DATA

Test Data Distribution ———
Theoretical Distribution - - - - -

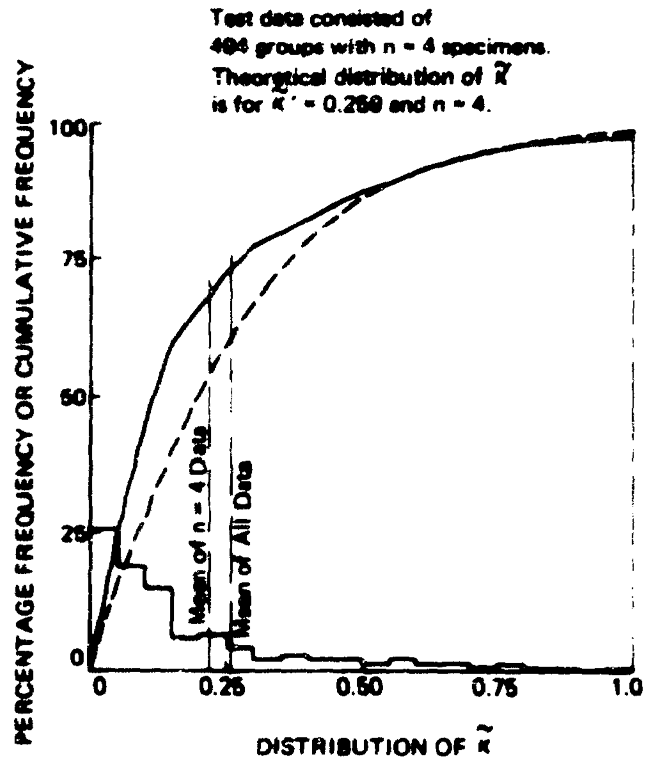


Figure 21. *Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter, Using First Two-Ordered Failures of All Collected Data of Sample Size = 4*

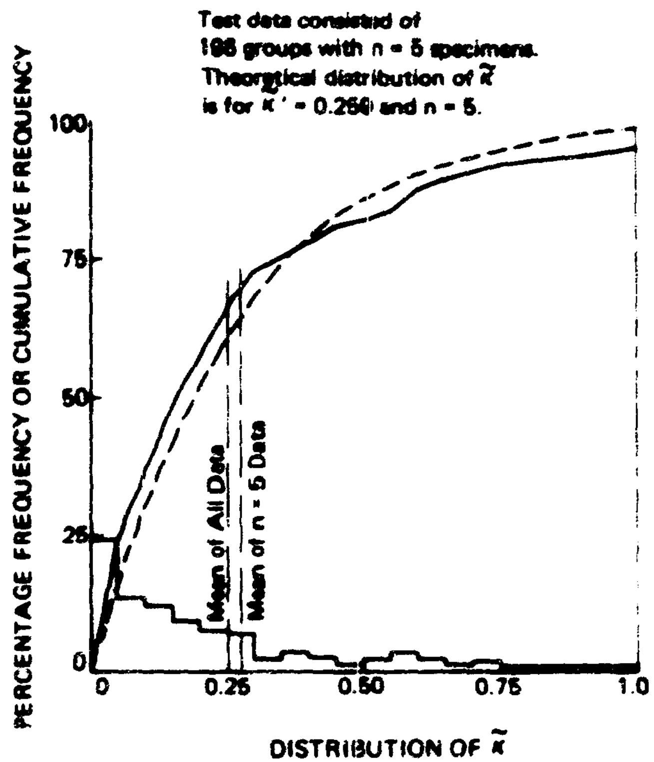


Figure 22. *Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter, Using First Two-Ordered Failures of All Collected Data of Sample Size = 5*

ALUMINUM FATIGUE TEST DATA: TOTAL OF EXAMINED DATA

Test Data Distribution ———

Theoretical Distribution - - - -

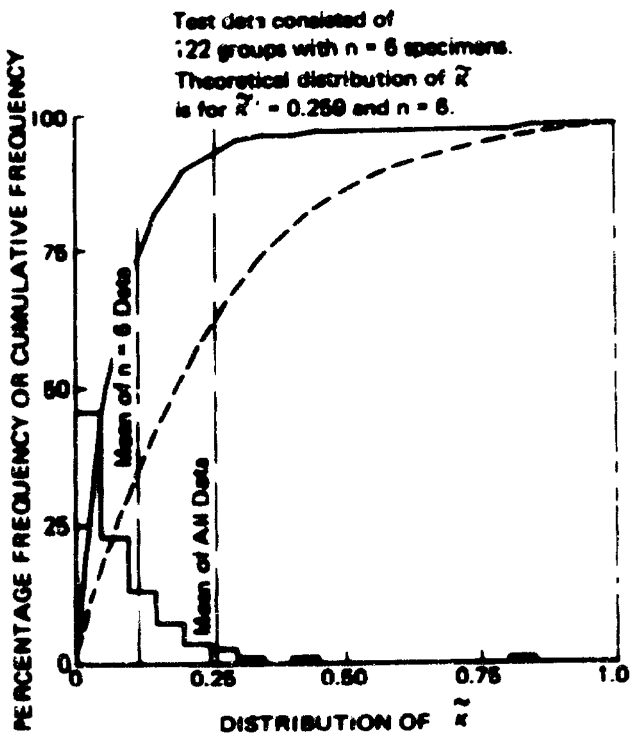


Figure 23. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter, Using First Two-Ordered Failures of All Collected Data of Sample Size = 6

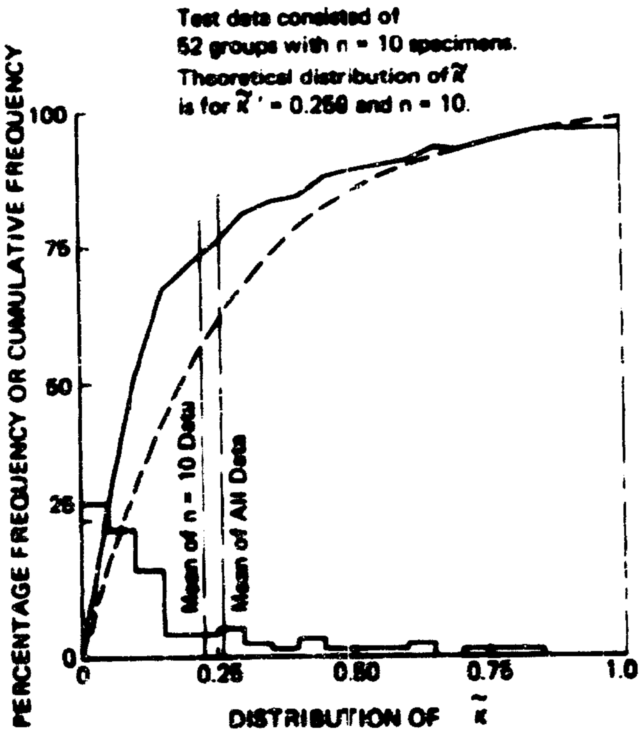
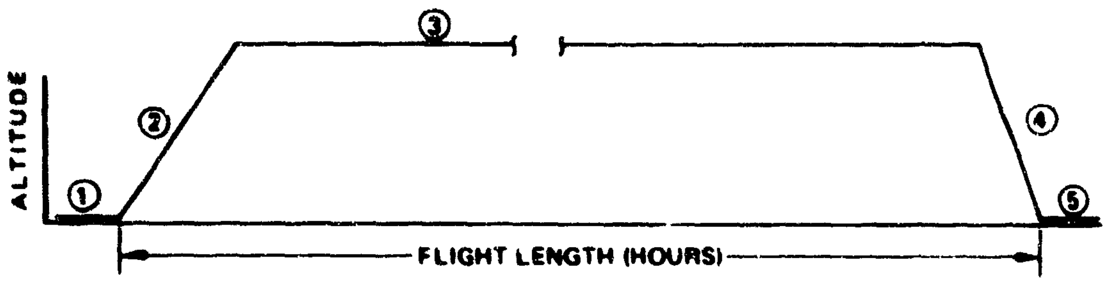


Figure 24. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter, Using First Two-Ordered Failures of All Collected Data of Sample Size = 10



① Taxi and Takeoff
② Climb to Cruise Altitude
③ Cruise at Cruise Altitude
④ Descent (Gear Down)
⑤ Landing and Taxi in

Figure 25 Typical Flight Profile for a Military Jet Tanker/Transport Airplane

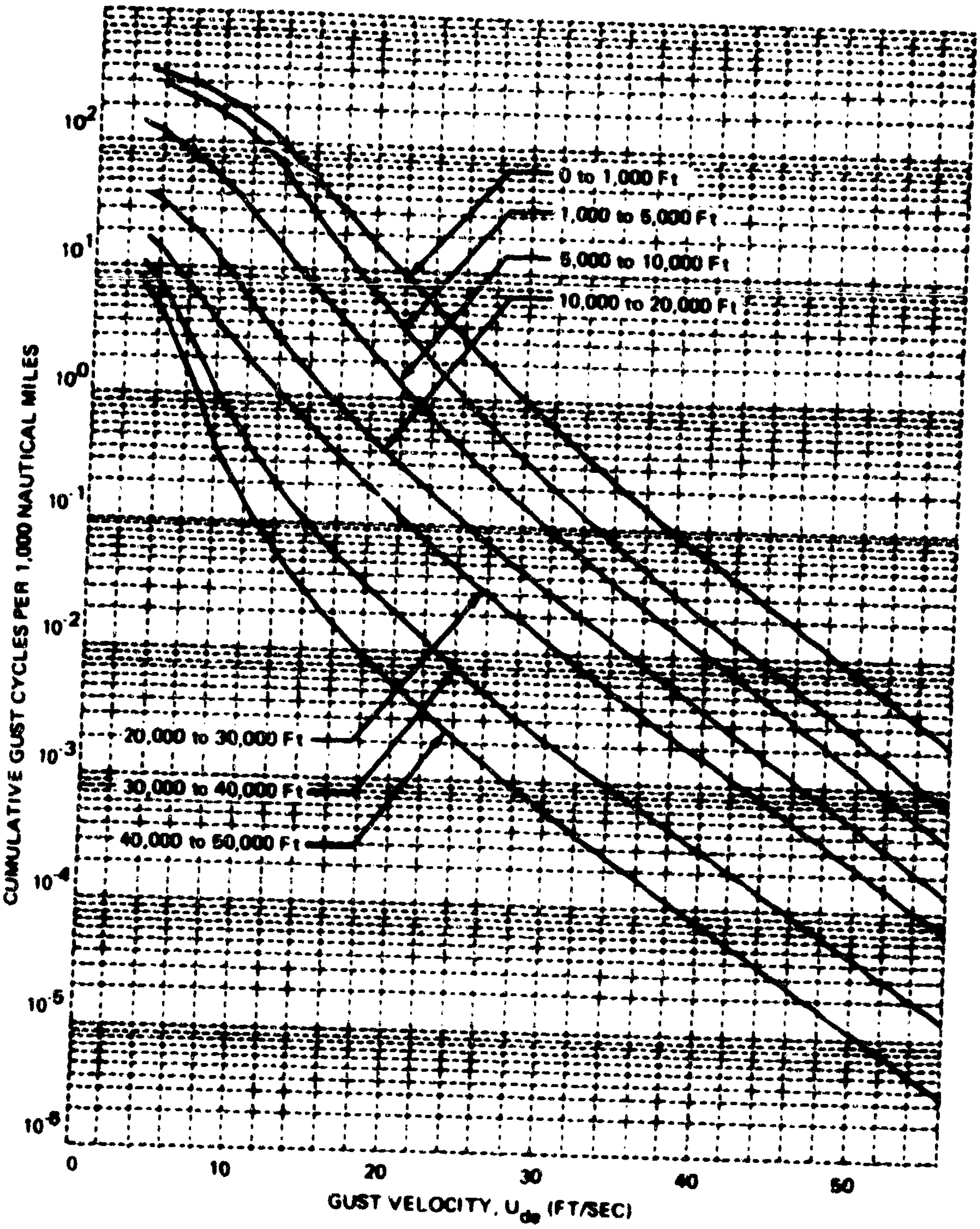


Figure 26. Gust Spectrum From SAC VGH Data on Military Jet Tanker/Transport Airplane

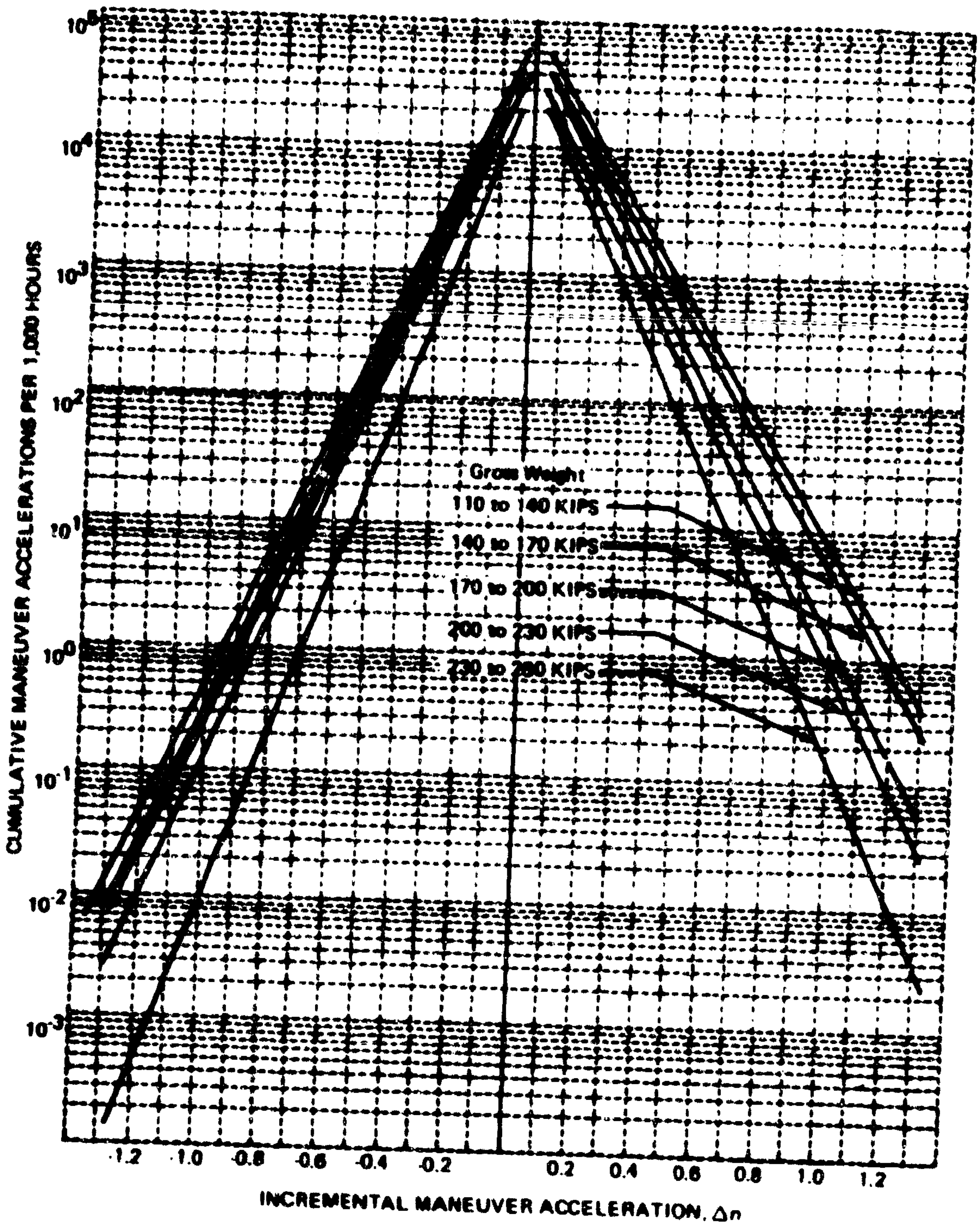


Figure 27. Maneuver Spectrum From SAC VGH Data on Military Jet Tanker/Transport Airplane

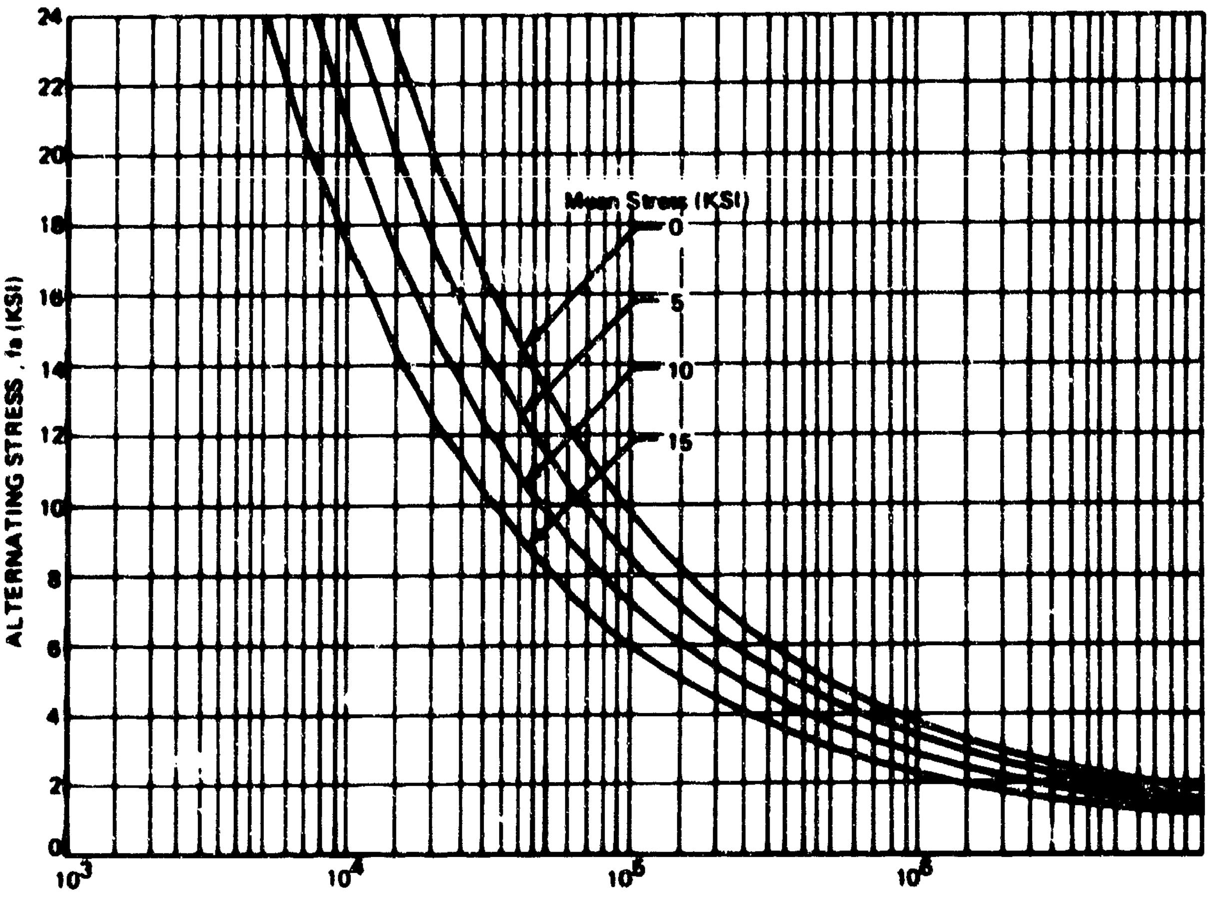


Figure 28. Typical Family of S-N Diagrams for a Structural Component on a Military Jet Tanker/Transport Airplane

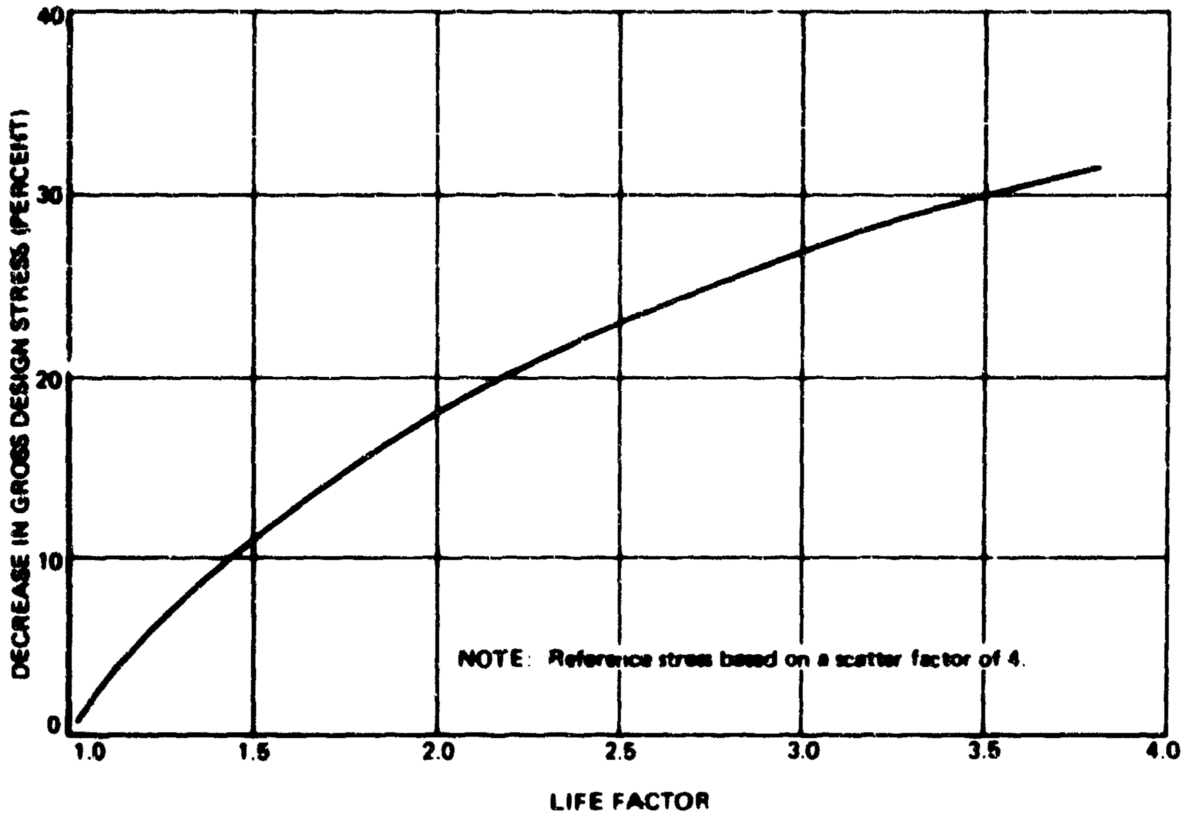


Figure 29. Relationship of Fatigue Life With Stress for the Fatigue-Critical Aluminum Structure of the Reference Military Tanker/Transport Airplane

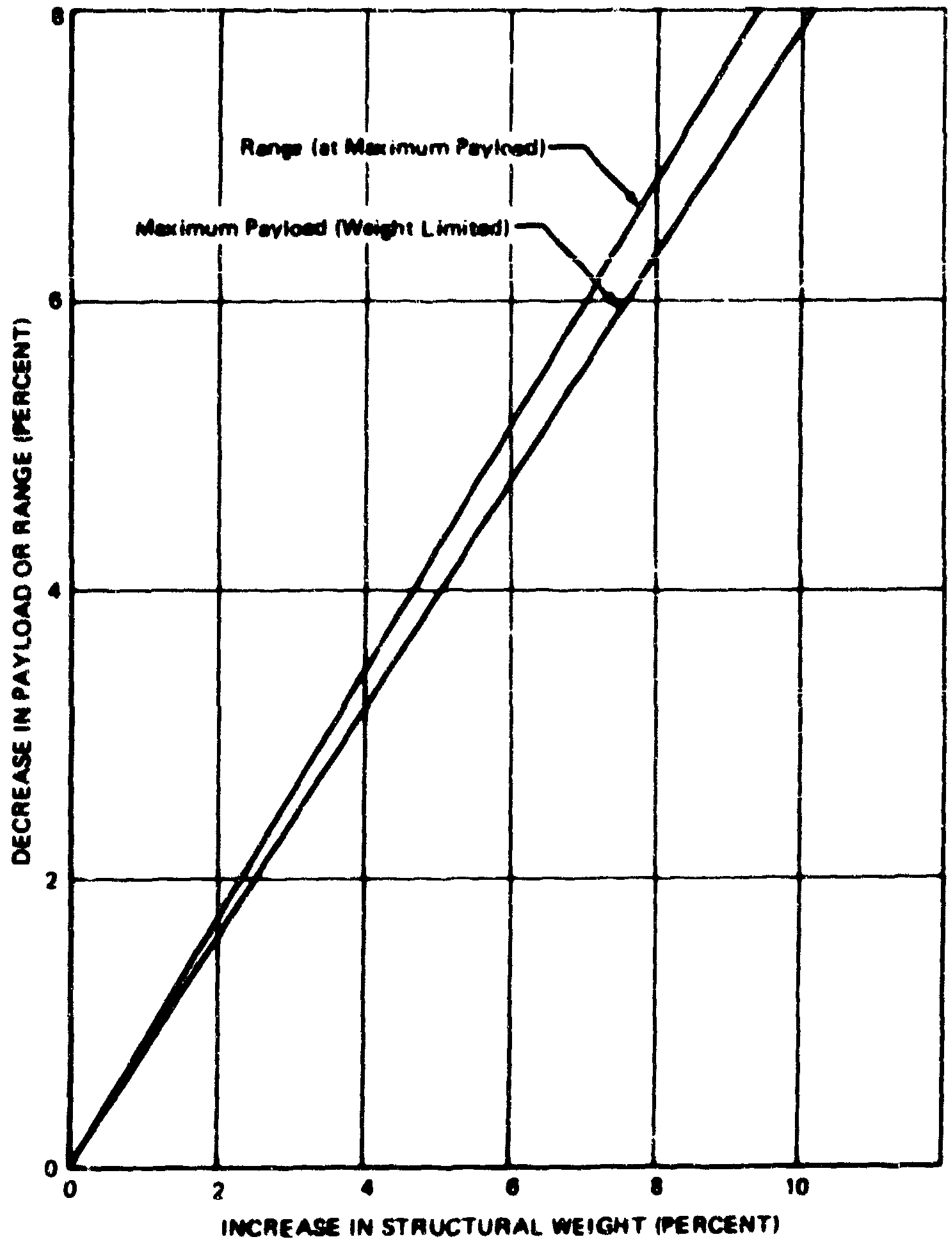


Figure 30. Relationship of Primary Structural Weight With Payload and Range of the Reference Military Tanker/Transport Airplane

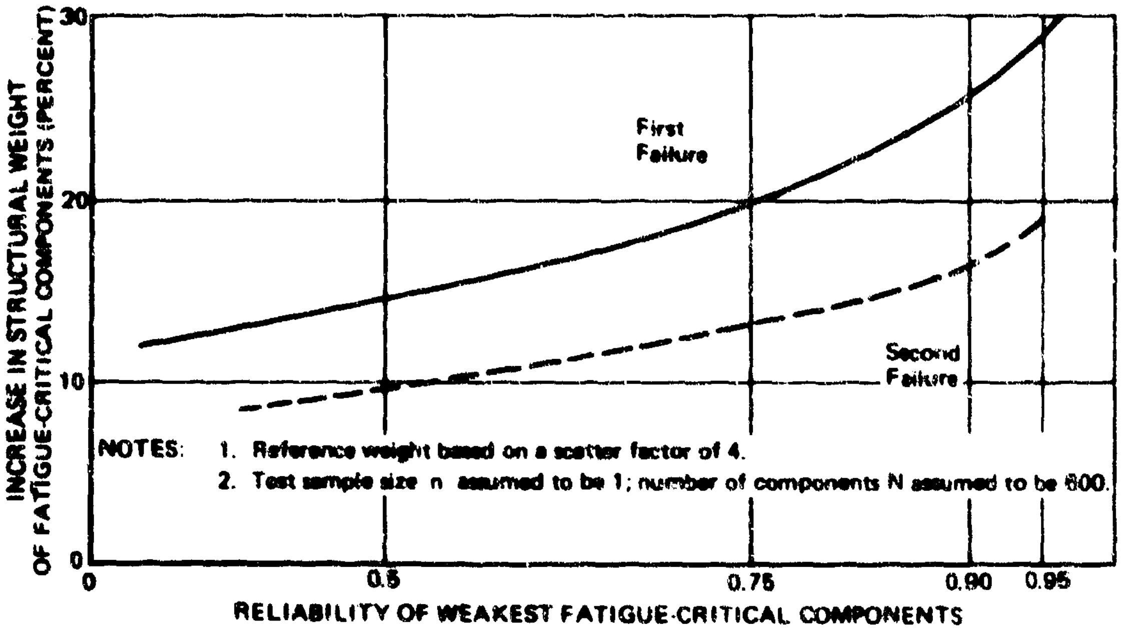


Figure 31. Relationship of Structural Weight of Fatigue-Critical Component With Degree of Reliability of Weakest Components

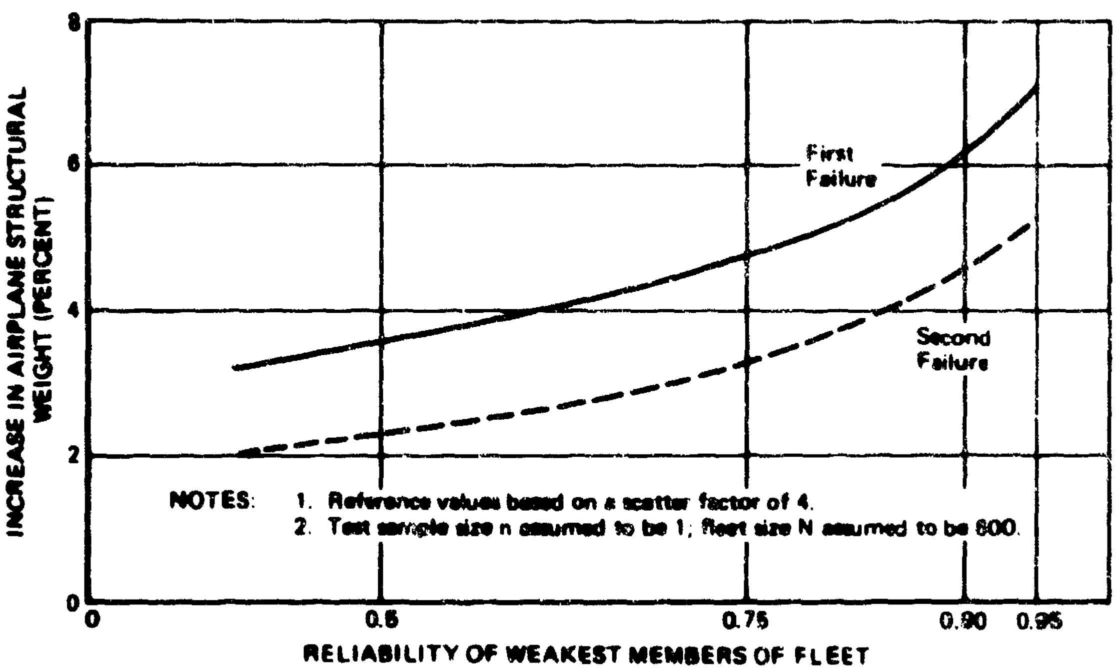


Figure 32. Relationship of Primary Structural Weight With Degree of Reliability of Weakest Members in Fleet, Military Tanker/Transport Airplane

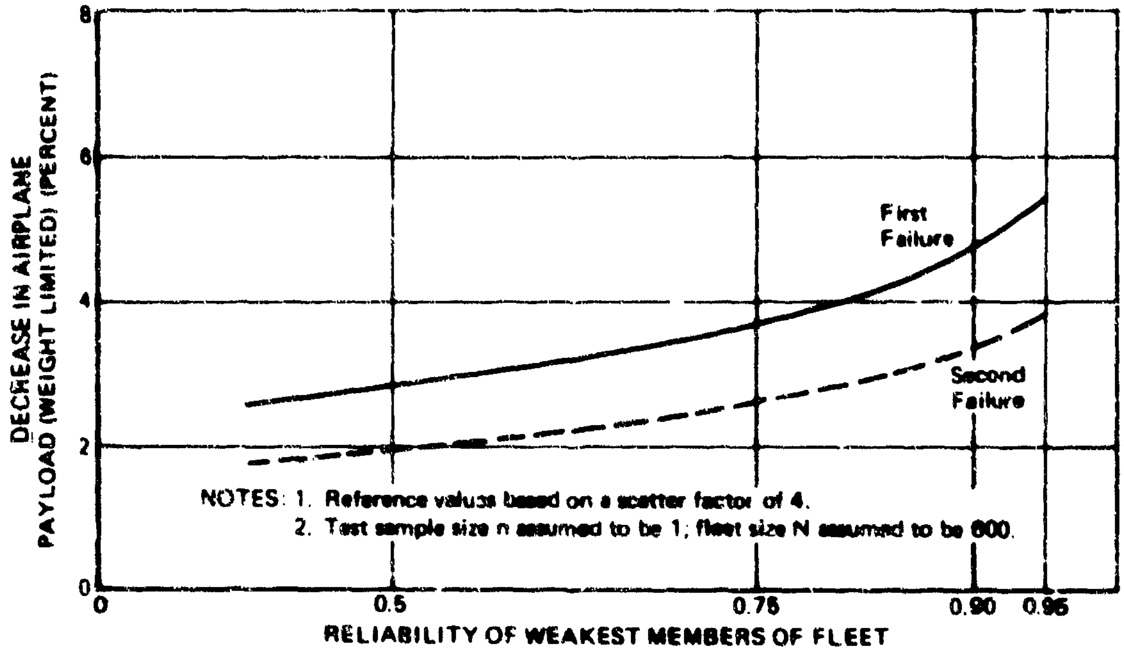


Figure 33. Relationship of Airplane Payload With Degree of Reliability of Weakest Members in Fleet, Military Tanker/Transport Airplane

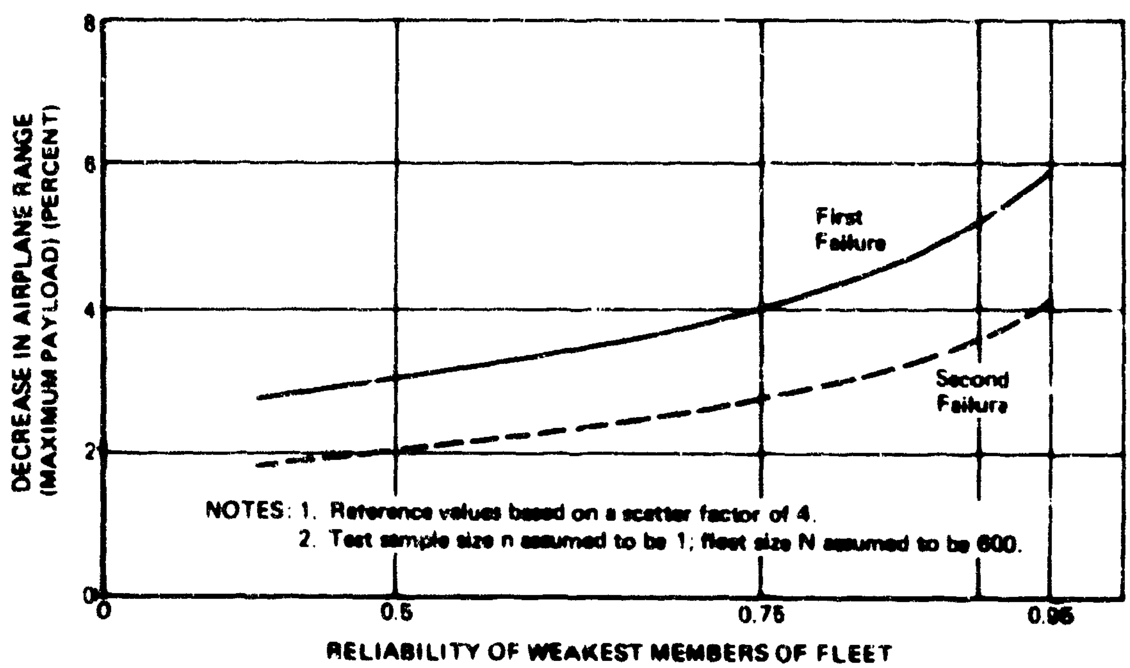


Figure 34. Relationship of Airplane Range With Degree of Reliability of Weakest Memeber in Fleet, Military Tanker/Transport Airplane

ALUMINUM FATIGUE TEST DATA

(Limited to simple notched, joints, and structures, excluding low amplitude, high-cycle data)

Distribution for Complete Groups - - - - - -
Distribution for Censored Groups ————

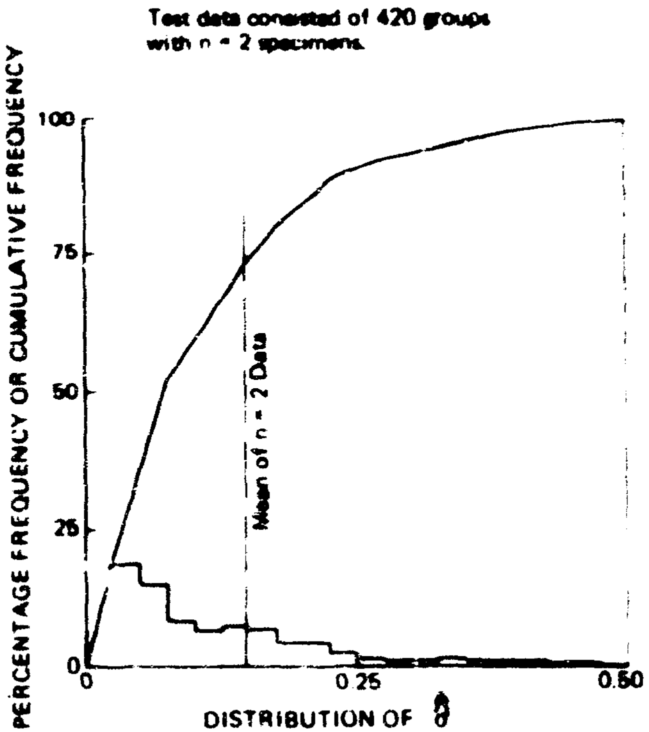


Figure 35. Distribution of the Observed Estimates of the Log-Normal Shape Parameter for All Qualified Data of Sample Size = 2

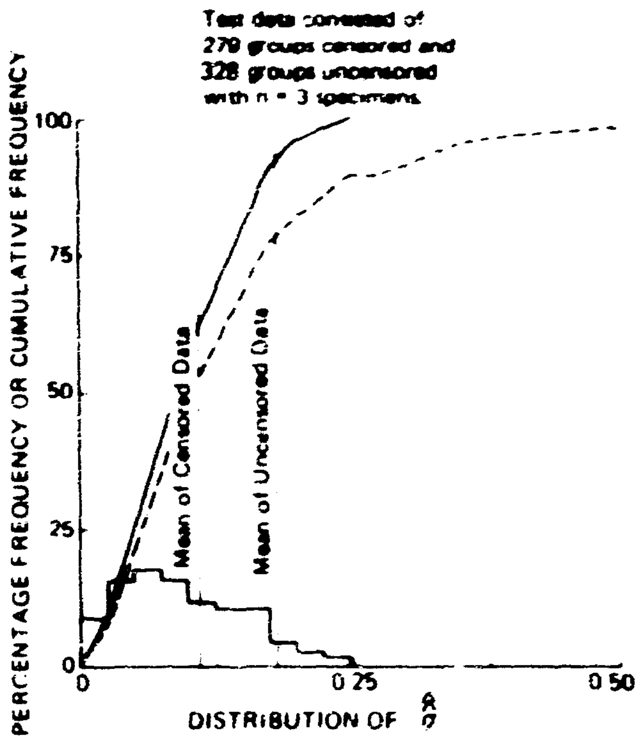


Figure 36. Comparison of the Distributions of Observed Estimates of the Log-Normal Shape Parameter Obtained From Uncensored and Censored Data (All Qualified Data of Sample Size = 3)

ALUMINUM FATIGUE TEST DATA

(Limited to simple notched, joints, and structures, excluding low-amplitude, high-cycle data)

Distribution for Complete Groups – – – – – –
Distribution for Censored Groups ————

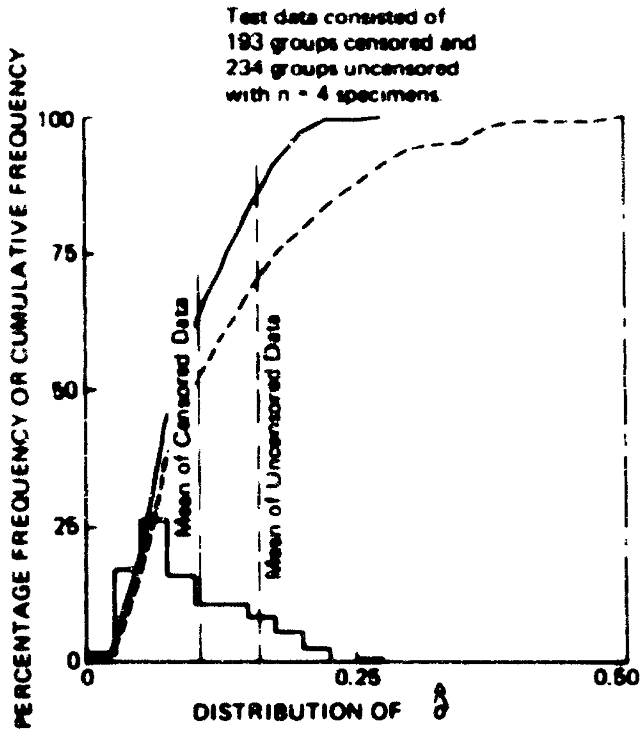


Figure 37. Comparison of the Distributions of Observed Estimates of the Log-Normal Shape Parameter Obtained From Uncensored and Censored Data (All Qualified Data of Sample Size = 4)

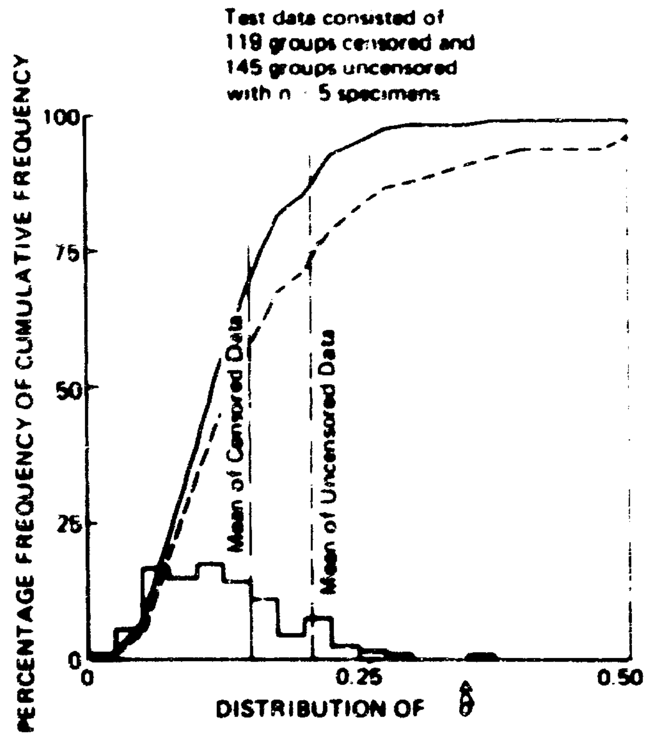


Figure 38. Comparison of the Distributions of Observed Estimates of the Log-Normal Shape Parameter Obtained From Uncensored and Censored Data (All Qualified Data of Sample Size = 5)

ALUMINUM FATIGUE TEST DATA

(Limited to simple notched, joints, and structures, excluding low-ampli…de, high-cycle data)

Test Data Distribution

Theoretical Distribution: $\sigma = \hat{\sigma}^* = 0.135$ – – – – – –

Theoretical Distribution: $\sigma = \hat{\sigma}_{0.95} = 0.139$ —— - ——

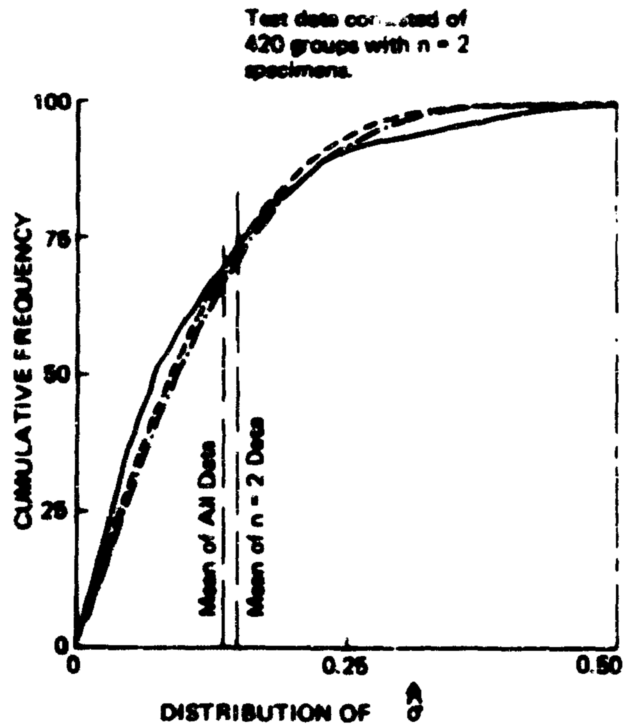


Figure 39. Comparison of the Theoretical and Observed Distributions of Estimates of the Log-Normal Shape Parameter for Sample Size = 2

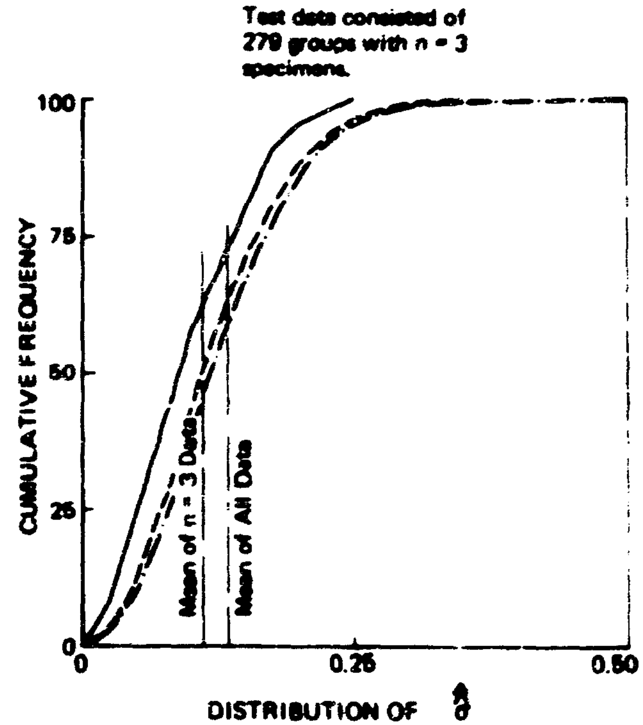


Figure 40. Comparison of the Theoretical and Observed Distributions of Estimates of the Log-Normal Shape Parameter for Sample Size = 3

ALUMINUM FATIGUE TEST DATA

(Limited to simple notched, joints, and strursures, excluding low-amplitude, high-cycle data)

Test Data Distribution

Theoretical Distribution: $\sigma = \hat{\sigma}^{*} = 0.135$ - - - - -

Theoretical Distribution: $\sigma = \hat{\sigma}^{*}_{0.95} = 0.139$ — - — - —

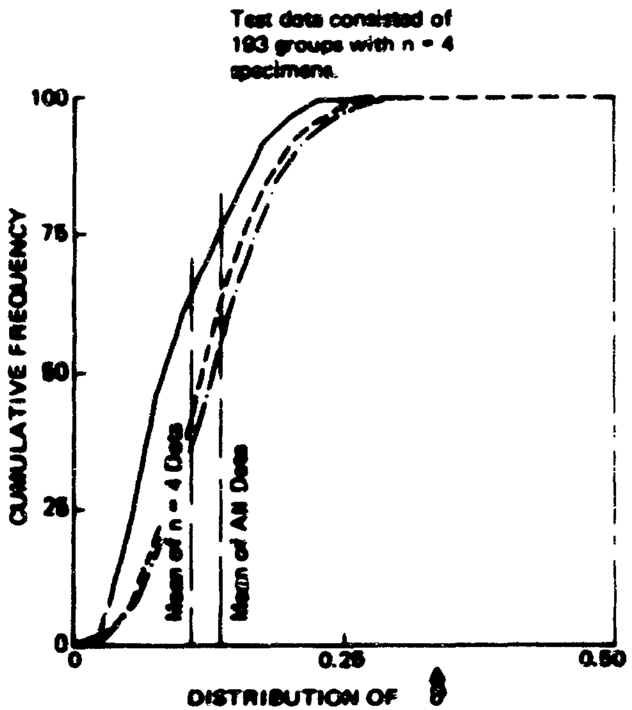


Figure 41. Comparison of the Theoretical and Observed Distributions of Estimates of the Log-Normal Shape Parameter for Sample Size = 4

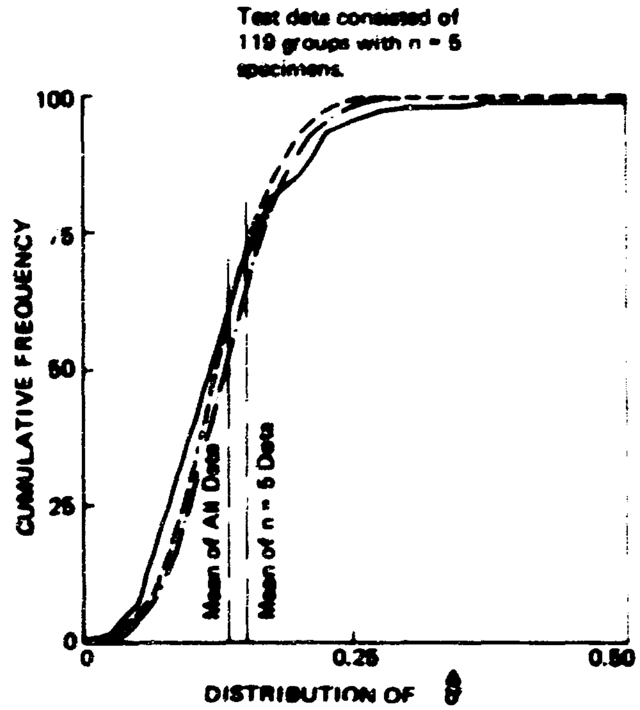


Figure 42. Comparison of the Theoretical and Observed Distributions of Estimates of the Log-Normal Shape Parameter for Sample Size = 5

ALUMINUM FATIGUE TEST DATA: CENSORED MLE-QUALIFIED DATA

Test Data Distribution ———

Theoretical Distribution - - - - -

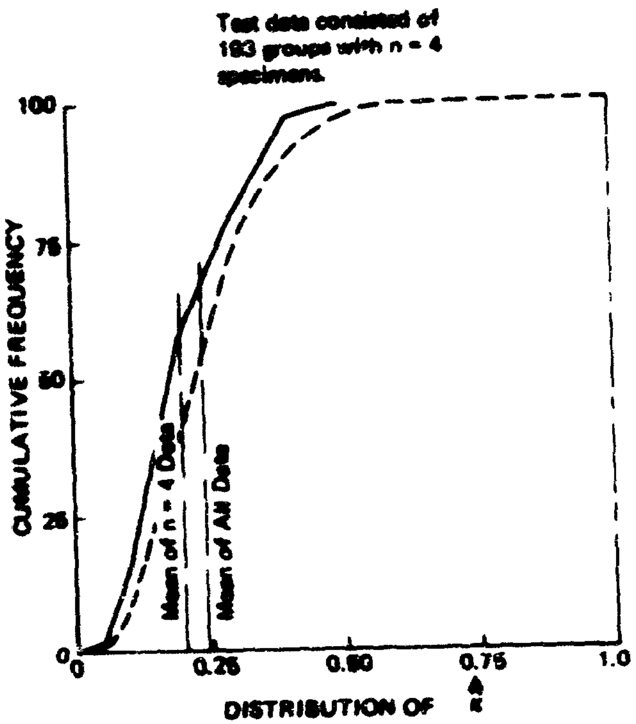


Figure 43. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter Using Censored MLE-Qualified Data of Sample Size = 4

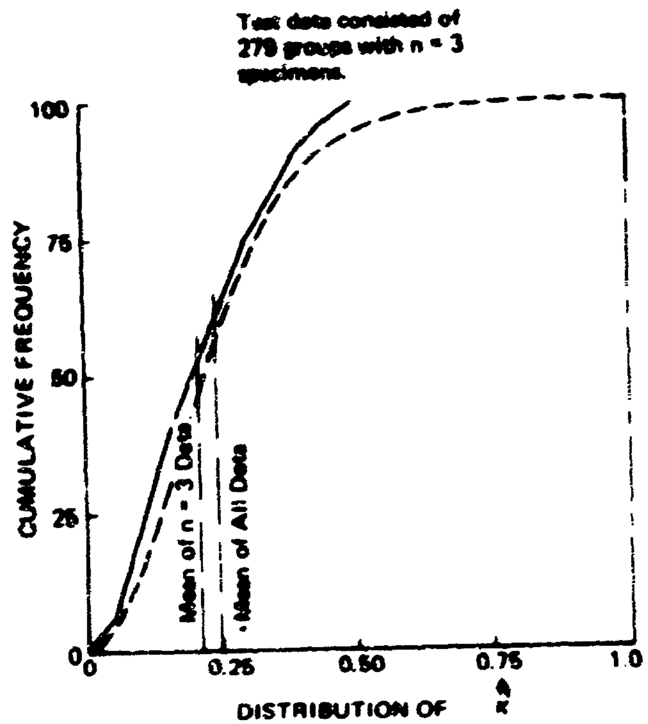


Figure 44. Comparison of the Theoretical and Observed Distributions of Estimates of the Weibull Shape Parameter Using Censored MLE-Qualified Data of Sample Size = 3

NOTE: Data based o[illegible] fleet size of 800 and on a 95% confidence interval estimate from one fatigue life observation.

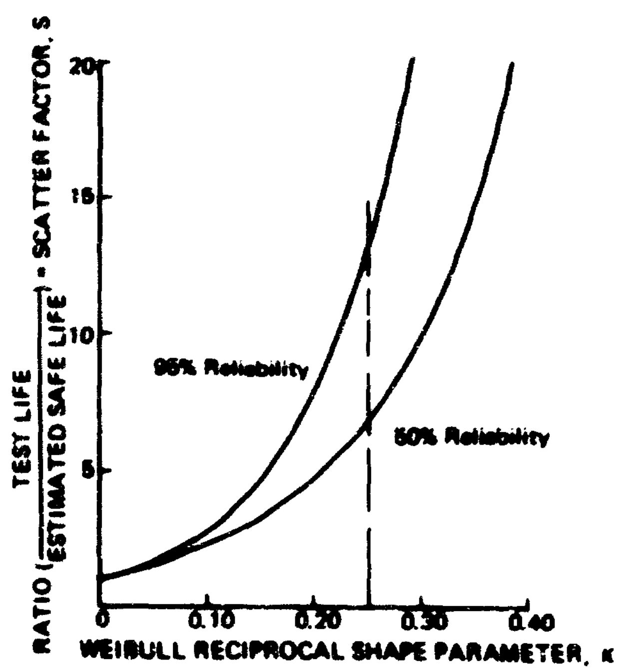


Figure 45. Scatter Factors Required To Attain 50% and 95% Fleet Reliability as a Function of True Value of the Distribution Shape Parameters, Weibull Model

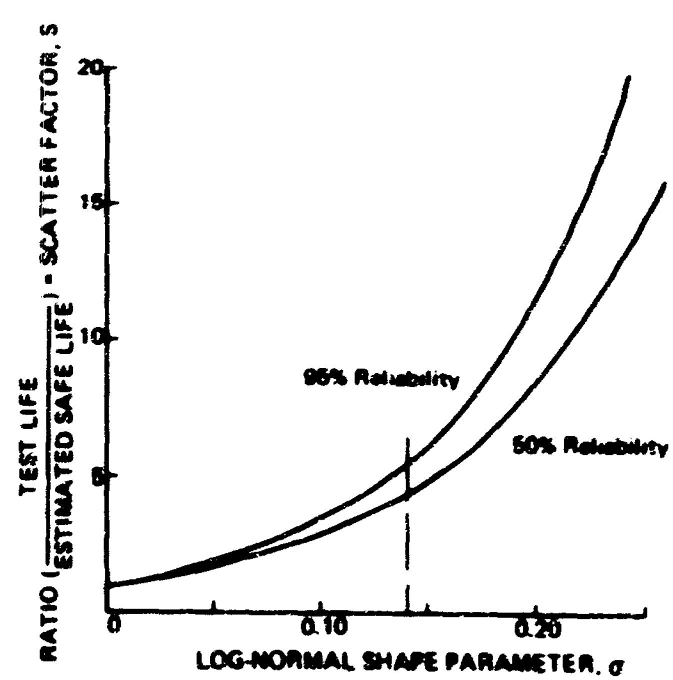


Figure 46. Scatter Factors Required To Attain 50% and 95% Fleet Reliability as a Function of True Value of the Distribution Shape Parameters, Log-Normal Model

NOTE: Data based on a fleet size of 600 and on a 95% confidence interval estimate from one fatigue life observation.

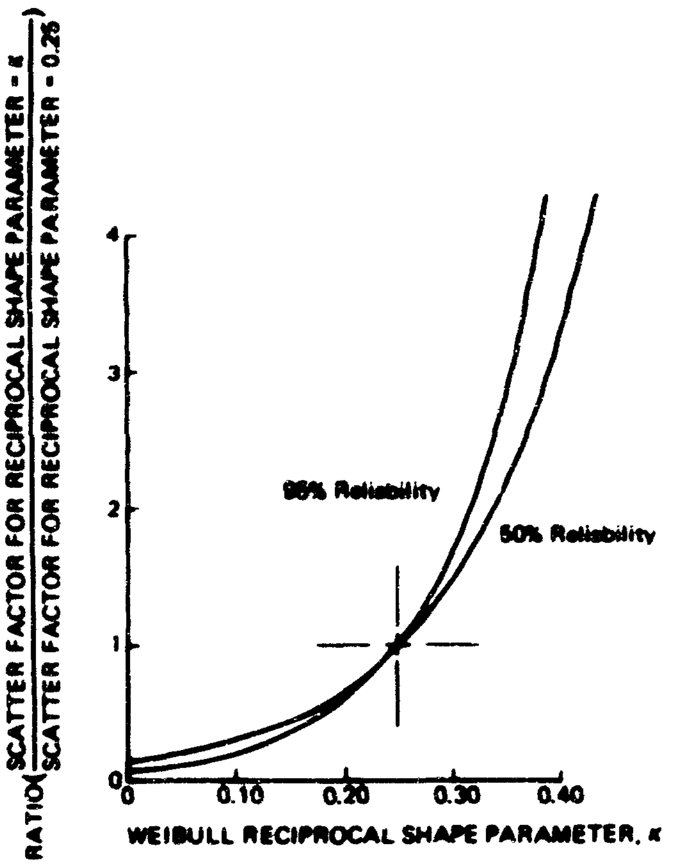


Figure 47. Effect of Distribution Shape Parameter Values on the Scatter Factors Used To Certify the Life of the "Weakest" in the Fleet, Weibull Model

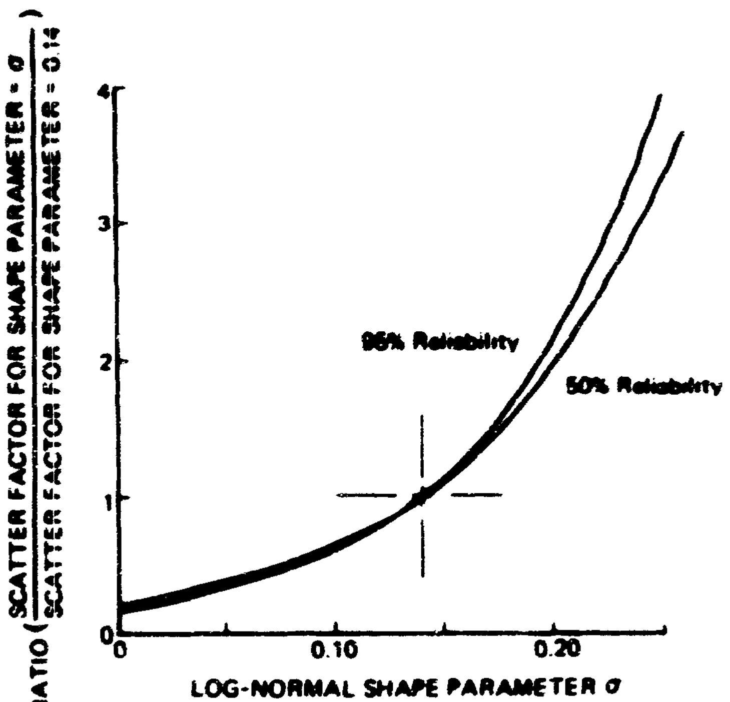


Figure 48. Effect of Distribution Shape Parameter Values on the Scatter Factors Used To Certify the Life of the "Weakest" in the Fleet, Log-Normal Model

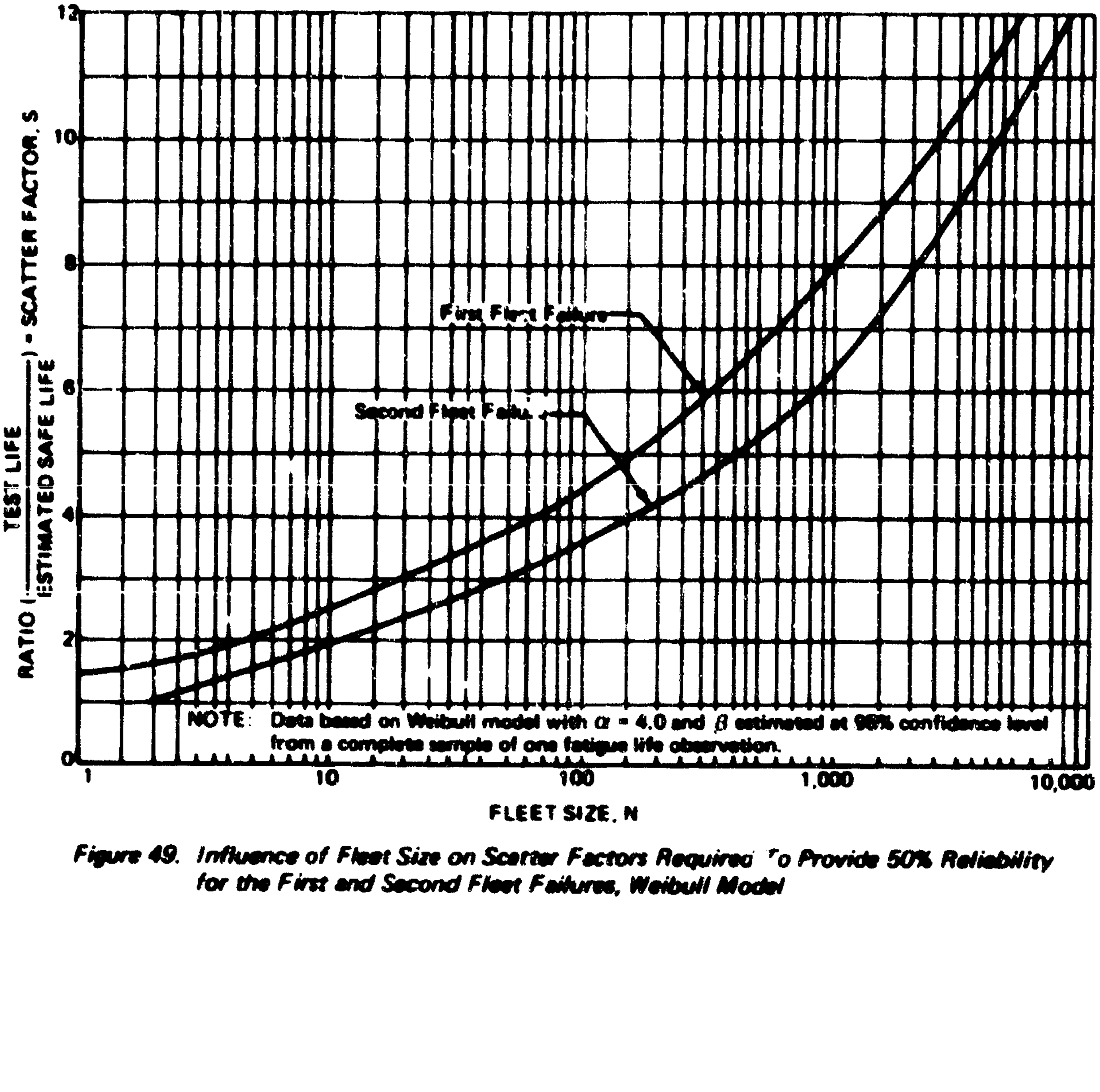


Figure 49. Influence of Fleet Size on Scatter Factors Required To Provide 50% Reliability for the First and Second Fleet Failures, Weibull Model

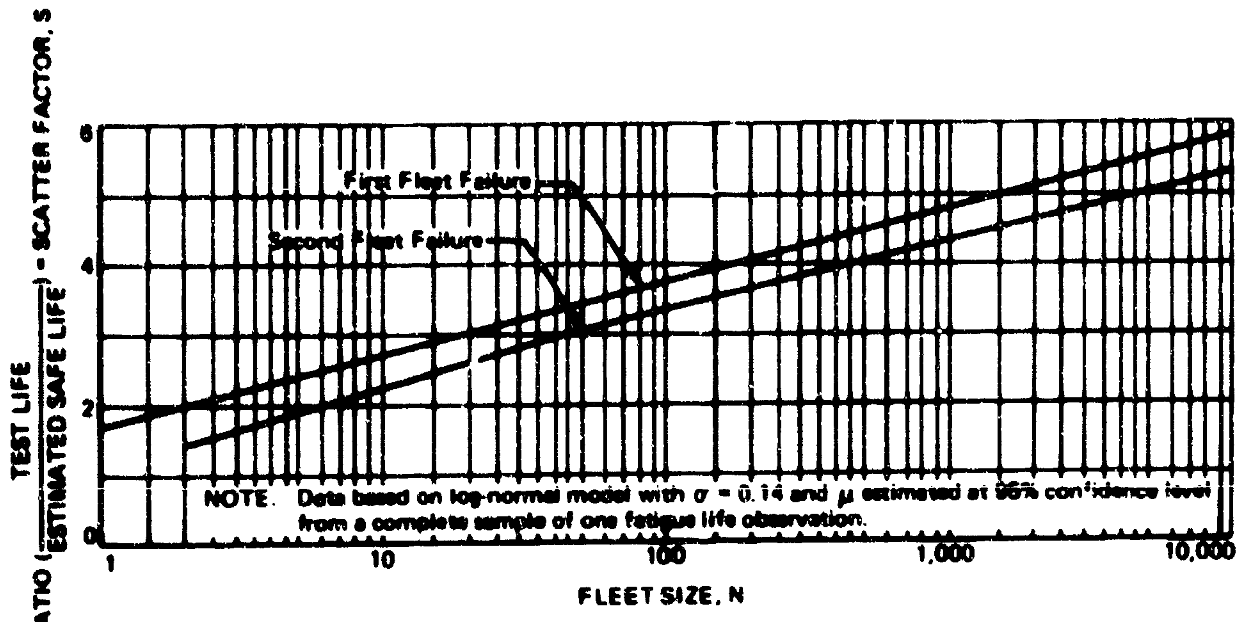


Figure 50. Influence of Fleet Size on Scatter Factors Required To Provide 50% Reliability for the First and Second Fleet Failures, Log-Normal Model

Table I. Simulated Examples To Illustrate the Effects of Isolated Long-Life Specimens

Example	Fatigue life (cycles)	Estimates of: Log-average life μ (cycles)	Log-standard deviation σ	Characteristic life β (cycles)	Weibull shape α	Point estimates of life (cycles) at some failure probabilities: Log-normal	Weibull
1	42,000					50% = 69,438	71,480
	45,000					10% = 22,514	8,554
	48,000					5% = 16,360	3,800
	52,000	69,440	0.3817	108,040	0.887	1% = 8,989	605
	55,000					0.1% = 4,594	45
	60,000					0.01% = 2,644	3
	500,000						
2	5,000					50% = 35,965	41,273
	42,000					10% = 11,668	19,662
	45,000					5% = 8,480	14,811
	48,000	35,970	0.3815	47,680	2.541	1% = 4,661	7,798
	52,000					0.1% = 2,383	3,145
	55,000					0.01% = 1,372	1,270
	60,000						

Table II. Simulated Examples to Illustrate Censoring Procedure

	Example 1			Example 2			Example 3		
	Fatigue life (cycles)	Log-standard deviation $\hat{\sigma}$	Weibull shape $\hat{\alpha}$ ($\hat{\gamma}$)	Fatigue life (cycles)	Log-standard deviation $\hat{\sigma}$	Weibull shape $\hat{\alpha}$ ($\hat{\gamma}$)	Fatigue life (cycles)	Log-standard deviation $\hat{\sigma}$	Weibull shape $\hat{\alpha}$ ($\hat{\gamma}$)
Original estimate	42,000 45,000 48,000 52,000 55,000 60,000	0.06	9.07 (0.11)	42,000 45,000 48,000 52,000 55,000 60,000 400,000 500,000	0.44	0.95 (1.05)	4,000 5,000 42,000 45,000 48,000 52,000 55,000 60,000	0.49	1.63 (0.61)
Second estimate				42,000 45,000 48,000 52,000 55,000 60,000 400,000 400,000 →	0.44	1.05 (0.95)	4,000 5,000 42,000 45,000 48,000 52,000 55,000 55,000 →	0.50	1.50 (0.67)
Third estimate				42,000 45,000 48,000 52,000 55,000 60,000 60,000 → 60,000 →	0.07	9.07 (0.11)	4,000 5,000 42,000 45,000 48,000 52,000 52,000 → 52,000 →	0.55	1.35 (0.74)
Fourth estimate				42,000 45,000 48,000 52,000 55,000 55,000 → 55,000 → 55,000 →	0.06	11.70 (0.085	4,000 5,000 42,000 45,000 48,000 48,000 → 48,000 → 48,000 →	0.62	1.20 (0.83)
Answer	Because original was O.K., no attempt was made to censor.			Third estimate	0.07	9.07	Original estimate	0.49	1.63

Table III. Seven Empirical Distributions of the Parameter-Free Statistic $1/U = \alpha/\hat{\alpha}$

NOTE: Tabulated values are $L_b(1/U)$, where $P[1/U > L_b(1/U)]$ $1-\gamma$

Coefficient of confidence γ \ Sample size n	2	3	4	5	10	20	Censored 3 of 5
0.01	(0.008)[b] 0.01	0.08	0.15	0.22	0.44	0.50	0.08
0.05	(0.042) 0.05	0.17	0.26	0.35	0.55	0.68	0.16
0.10	(0.084) 0.09	0.24	0.36	0.44	0.63	0.74	0.23
0.25	(0.213) 0.22	0.42	0.52	0.60	0.75	0.84	0.37
0.50	(0.458) 0.46	0.66	0.75	0.80	0.90	0.95	0.61
0.75	(0.811) 0.84	0.96	1.01	1.05	1.07	1.07	0.95
0.90	(1.228) 1.25	1.30	1.30	1.28	1.25	1.18	1.29
0.95	(1.528) 1.54	1.54	1.50	1.46	1.35	1.25	1.60
0.99	(2.207) 2.20	2.08	1.80	1.79	1.58	1.40	2.14
Smallest of 2,000[a]	(0.0008) 0.001	0.018	0.07	0.08	0.26	0.44	0.04
Mean	(0.578) 0.58	0.73	---	0.84	0.92	0.95	---
Variance of distribution	(0.238) 0.24	0.19	---	0.12	0.06	0.03	---
Largest of 2,000[a]	(3.449) 3.41	3.02	3.00	2.25	2.18	1.62	2.9

[a]For each sample size, $1/U$ was calculated for each of 2,000 independent groups of generated exponential ($\alpha = 1$) variates. The empirical distributions were taken to be the ordered arrays of these estimates.

[b]Values in parentheses are obtained from theory.

Table IV. Seven Empirical Marginal Distributions of the Parameter-Free Statistic $V = (\hat{\beta}/\beta)^{\hat{\alpha}}$

NOTE: Tabulated values are v, where $P(V \leq v) = \gamma$

Coefficient of confidence γ \ Sample size n	2	3	4	5	10	20	Censored 3 of 5
0.01	10^{-15}	0.0005	0.03	0.10	0.39	0.54	10^{-5}
0.10	0.01	0.19	0.31	0.44	0.62	0.72	0.05
0.25	0.23	0.45	0.58	0.64	0.79	0.84	0.25
0.50	0.81	0.87	0.97	0.95	1.00	0.99	0.69
0.75	2.08	1.64	1.55	1.41	1.26	1.17	1.24
0.90	11.0	3.6	2.70	2.17	1.60	1.39	1.86
0.95	70.0	6.4	4.08	3.1	1.83	1.53	2.6
0.98	5,000.0	17.0	7.7	5.2	2.21	1.75	4.2
0.99	10^{7}	80.0	17.0	8.0	2.7	1.89	8.[illegible]
Smallest of 2,000*	10^{-30}	10^{-9}	5×10^{-6}	0.0004	0.137	0.39	10^{-10}
Mean	10^{22}	10^{6}	3.1	1.38	1.08	1.03	1.30
Largest of 2,000*	10^{26}	10^{9}	78.0	100.0	7.4	2.68	400.0
Variance of distribution	(10^{48})	(10^{16})	(80)	(10)	(0.24)	(0.078)	(100)

*For each sample size, V was calculated for each of 2,000 independent groups of generated exponential ($\alpha = 1$) variates. The empirical distributions were taken to be the ordered arrays of these estimates.

Table V. Some Theoretical Distributions of the Parameter-Free Statistic $W = (\hat{\beta}/\beta)^{\alpha}$

NOTES: 1. Tabulated values are w, where $P(W < w) = \gamma$

2. From theory, $E(W) = 1$

$$\mathrm{Var}(W) = 1/n_f$$

Coefficient of confidence γ \ Number of failure observations in sample n_f	1	2	3	5	10
0.01	0.010	0.07	0.14	0.26	0.41
0.02	0.020	0.11	0.19	0.31	0.46
0.05	0.05	0.18	0.27	0.39	0.54
0.10	0.11	0.27	0.37	0.49	0.62
0.20	0.22	0.41	0.51	0.62	0.73
0.30	0.36	0.55	0.64	0.73	0.81
0.50	0.69	0.84	0.89	0.93	0.97
0.70	1.20	1.22	1.21	1.18	1.13
0.80	1.61	1.50	1.43	1.34	1.25
0.90	2.30	1.94	1.77	1.60	1.42
0.95	3.00	2.37	2.10	1.83	1.57
0.98	3.91	2.92	2.51	2.11	1.75
0.99	4.61	3.32	2.80	2.32	1.87

Table VI. Results of Analyses Determining the Typical Shape Parameters for Fatigue Performance of Aluminum Structures

Data description	Number of groups	Unbiased estimate $\hat{\kappa}'$ of reciprocal shape parameter κ
All collected data	2,003	0.259
All unqualified data	705	0.325
All qualified data: Limited to simple notched, joints, and structures, excluding low-amplitude, high-cycle data	1,298	0.224
All qualified data:		
2024	551	0.213
7075	482	0.227
7178	125	0.246
Monolithic notched	444	0.240
Laboratory structures simulator	557	0.200
Full-scale structures	297	0.243
Constant amplitude	1,174	0.229
Variable amplitude	124	0.177
* Bonded	83	0.419
* Low amplitude, high life	111	0.419
* Unnotched	179	0.110
70 to 10^3 cycles	50	0.240
10^3 to 10^4 cycles	168	0.215
10^4 to 6×10^4 cycles	434	0.204
6×10^4 to 4×10^5 cycles	444	0.259
4×10^5 to 10^6 cycles	78	0.227

*Rejected data

Table VII. Comparison of Results Between Uncensored Fatigue Data and Data Censored for High-Time Outliers

	Size of groups (n specimens)	Weibull model	
		Number of groups	Unbiased estimate $\tilde{\kappa}, \tilde{\kappa}'$ of reciprocal shape parameter κ
MLE-uncensored	2	420	0.253
	3	328	0.301
	4	234	0.286
	5	145	0.380
	Weighted value of all groups	1,250	0.300
MLE-censored	2	420	0.253
	3	279	0.211
	4	193	0.201
	5	117	0.270
	Weighted value of all groups	1,119	0.242
Estimate from first two-ordered failures	2	420	0.253
	3	330	0.229
	4	236	0.200
	5	151	0.227
	Weighted value of all groups	1,298	0.224

Table VIII. Comparison of Results From Total Collected Fatigue Data and Qualified Structural-Equivalent-Type Data

	Sample size n	Number of samples	$\tilde{\kappa}'$	Observed Var $\tilde{\kappa}$	Theoretical* Var $\tilde{\kappa}$ (for $\kappa = \tilde{\kappa}'$)	Theoretical* Var $\tilde{\kappa}$ (for $\kappa = 0.224$)
Total collected fatigue test data	2	524	0.293	0.1056	0.0611	0.0357
	3	431	0.304	0.1526	0.0756	0.0410
	4	494	0.215	0.0855	0.0401	0.0435
	5	196	0.273	0.1271	0.0667	0.0449
Only qualified fatigue test data	2	420	0.253	0.0585	0.0456	0.0357
	3	330	0.229	0.0537	0.0429	0.0410
	4	236	0.200	0.0391	0.0347	0.0435
	5	151	0.227	0.0841	0.0461	0.0449

*In theory, Var $\tilde{\kappa} = C_n \kappa^2$ [See Eq. (IV-14)]

where: $C_2 = 0.712$

$C_3 = 0.818$

$C_4 = 0.867$

$C_5 = 0.895$

Table IX. Scatter Fact rs To Obtain Reliability $\bar{R}$ in the <u>Weakest</u> of a Fleet of Size N, When n_f Specimens Are Tested to Failure (Weibull Model)

NOTES: 1. Data based on Weibull model with known shape parameters (α 4.0) and with unknown scale parameter β estimated at the 95% confidence level.

2. Scatter factor $\hat{\beta}/\check{Z}_{\bar{R}}$ S $S_{n_f} \cdot S_{\bar{R}} \cdot S_N$

Number of failures n_f in a complete or one-stage, type II, censored sample	S_{n_f}	Reliability $\bar{R}$	$S_{\bar{R}}$	Fleet size N	S_N
1	1.32	0.368 (characteristic life)	1.0	1	1.0
2	1.24	0.500 (median life)	1.096	3	1.316
3	1.20	0.507 (mean life)	1.102	10	1.777
4	1.18	0.750	1.365	20	2.12
5	1.16	0.900	1.755	50	2.66
10	1.12	0.950	2.10	100	3.16
∞	1.00	0.980	2.65	200	3.76
		0.990	3.16	500	4.74
		0.999	5.63	1,000	5.63
				10,000	10.0

$\hat{\beta}$ - MLE of Weibull scale (β) - $\left\{\frac{1}{n_f}\left[\sum_{1}^{n_f}\left(Y_i^{4.0}\right) + (n-n_f)\, Y_{n_f}^{4.0}\right]\right\}^{1/4.0}$

$\check{Z}_{\bar{R}}$ design or certifiable life

Table X. Scatter Factors To Obtain Reliability $\bar{R}$ in the Second Weakest of a Fleet of Size N, when n_f Specimens Are Tested to Failure (Weibull Model)

NOTES: 1. Data based on Weibull model with known shape parameter (α = 4.0) and with unknown scale parameter β estimated at the 95% confidence level.
2. Scatter factor $\hat{\beta}/\check{Z}_{\bar{R}}$ S $S_{n_f} \cdot S_{\bar{R}} \cdot S_{N_{\bar{R}}}$

Number of failures n_f in a complete or one-stage, type II, censored sample	S_{n_f}	Reliability $\bar{R}$	$S_{\bar{R}}$	Fleet size N	$S_{N_{\bar{R}}}$ $\bar{R}$ 0.500	$S_{N_{\bar{R}}}$ $\bar{R}$ 0.750	$S_{N_{\bar{R}}}$ $\bar{R}$ 0.900	$S_{N_{\bar{R}}}$ $\bar{R}$ 0.950
1	1.32	0.50	1.10	10	1.40	1.30	1.14	1.08
2	1.24	0.75	1.37	50	2.12	1.96	1.78	1.67
3	1.20	0.90	1.76	200	3.0	2.77	2.50	2.38
4	1.18	0.95	2.10	1,000	4.5	4.2	3.7	3.5
5	1.16							
10	1.12							
∞	1							

$\hat{\beta}$ MLE of Weibull scale (β) $\left\{\frac{1}{n_f}\left[\sum_{i=1}^{n_f} (Y_i^{4.0}) + (n-n_f)Y_{n_f}^{4.0}\right]\right\}^{1/4.0}$

$\check{Z}_{\bar{R}}$ design or certifiable life

Table XI. Comparison of Predicted Performance and Fleet Experience

Aircraft type	Fatigue package number	Structural detail	Safe-life based on a scatter factor of 4		Number of airplanes modified as of Jan. 1969	Total number of airplanes in fleet	Table IX median time to first failure in fleet		Range of life during which fatigue package was installed based on scatter factor=4 (hours)	Observed first failure time (hours)
			Test (hours)	Calculation (hours)			For inspected fleet (hours)	For total fleet (hours)		
A	I	1	4,600	---	268	592	3,200	2,550	3,500 to 5,000	2,720
		2	---	4,600			3,200	2,550		None
		3	---	4,600			3,200	2,550		
		4	---	8,900			6,200	5,050		
		5	---	4,300			3,000	2,440		
		6	---	5,100	268	592	3,550	2,900	3,500 to 5,000	None
B	I	1	4,600	---	33	56	5,400	4,800	3,500 to 5,000	None
		2	---	4,600			5,400	4,800		
		3	---	4,600			5,400	4,800		
		4	---	8,900			10,500	9,200		
		5	---	4,300			5,100	5,300		
		6	---	5,100	33	56	6,000	6,200	3,500 to 5,000	None
C	I	1	---	6,000	11	11	---	9,350	4,500 to 6,000	None
		2	---	6,000			---	9,350		
		3	---	6,000			---	9,350		
		4	---	14,400			---	22,400		
		5	5,400	---			---	8,400		
		6	---	6,500			---	10,100		
		7	---	7,900			---	12,300		
		8	7,900	---	11	11	---	12,300	4,500 to 6,000	None

Table XI—Continued

Aircraft type	Fatigue package number	Structural detail	Safe-life based on a scatter factor of 4: Test (hours)	Safe-life based on a scatter factor of 4: Calculation (hours)	Number of airplanes modified as of Jan. 1969	Total number of airplanes in fleet	Table IX: median time to first failure in fleet: For inspected fleet (hours)	Table IX: median time to first failure in fleet: For total fleet (hours)	Range of life during which fatigue package was installed based on scatter factor 4 (hours)	Observed first failure time (hours)
D	I	1	---	6,000	10	10	---	9,500	4,500 to 6,000	None
		2	---	6,000			---	9,500		
		6	---	6,600			---	10,400		
		7	---	7,000			---	11,000		
		8	---	7,000	10	10	---	11,000	4,500 to 6,000	None
E	I	1	---	5,600	8	8	---	9,400	4,000 to 5,500	None
		2	---	5,600			---	9,400		
		3	---	5,600			---	9,400		
		4	---	13,400			---	22,500		
		5	---	6,200			---	10,400		
		6	---	7,200	8	8	---	12,100	4,000 to 5,500	None
F	I	1	---	6,000	6	6	---	10,900	4,500 to 6,000	None
		2	---	6,000			---	10,900		
		6	---	6,600			---	10,900		
		7	---	7,000			---	12,700		
		8	---	7,000	6	6	---	12,700	4,500 to 6,000	None
G	I	1	4,600	---	5	6	8,600	8,400	3,500 to 5,000	None
		2	---	4,600			8,600	8,400		
		3	---	4,600			8,600	8,400		
		4	---	8,900			16,700	16,200		
		5	---	4,300			8,100	7,800		
		6	---	5,100	5	6	9,600	9,100	3,500 to 5,000	None

Table XI—Continued

Aircraft type	Fatigue package number	Structural detail	Safe-life based on a scatter factor of 4		Number of airplanes modified as of Jan. 1969	Total number of airplanes in fleet	Table IX median time to first failure in fleet		Range of life during which fatigue package was installed based on scatter factor 4 (hours)	Observed first failure time (hours)
			Test (hours)	Calculation (hours)			For inspected fleet (hours)	For total fleet (hours)		
H	I	1	---	5,700	4	6	11,400	10,400	4,500 to 6,000	None
		2	---	5,700			11,400	10,400		
		3	---	5,700			11,400	10,400		
		4	---	13,500			27,000	24,500		
		5	---	7,400			14,800	13,400		
		6	---	8,600	4	6	17,200	15,600	4,500 to 6,000	None
J	I	1	---	6,500	5	5	---	12,200	5,000 to 6,500	None
		2	---	6,500			---	12,200		
		3	---	6,500			---	12,200		
		4	---	14,300			---	26,800		
		5	---	7,300			---	13,700		
		6	---	8,000	5	5	---	15,000	5,000 to 6,500	None
K	I	1	4,600	---	5	5	---	8,600	3,500 to 5,000	None
		2	---	4,600			---	8,600		
		3	---	4,600			---	8,600		
		4	---	8,900			---	16,700		
		5	---	4,300			---	8,100		
		6	---	5,100	5	5	---	9,600	3,500 to 5,000	None

Table XI—Continued

Aircraft type	Fatigue package number	Structural detail	Safe-life based on a scatter factor of 4: Test (hours)	Safe-life based on a scatter factor of 4: Calculation (hours)	Number of airplanes modified as of Jan. 1969	Total number of airplanes in fleet	Table IX median time to first failure in fleet: For inspected fleet (hours)	Table IX median time to first failure in fleet: For total fleet (hours)	Range of life during which fatigue package was installed based on scatter factor of 4 (hours)	Observed first failure time (hours)
L	I	1	4,600	---	2	4	10,400	9,100	3,500 to 5,000	None
		2	---	4,600			10,400	9,100		
		3	---	4,600			10,400	9,100		
		4	---	8,900			20,800	17,700		
		5	---	4,300			10,100	8,500		
		6	---	5,100	2	4	12,000	10,200	3,500 to 5,000	None
M	I	1	---	5,600	3	3	---	12,000	4,000 to 5,500	None
		2	---	5,600			---	12,000		
		3	---	5,600			---	12,000		
		4	---	13,400			---	28,600		
		5	---	6,200			---	13,200		
		6	---	7,200	3	3	---	15,400	4,500 to 5,500	None
N	I	1	4,600	---	2	2	---	10,400	3,500 to 5,000	None
		2	---	4,600			---	10,400		
		3	---	4,600			---	10,400		
		4	---	8,900			---	20,800		
		5	---	4,300			---	10,100		
		6	---	5,100	2	2	---	12,000	3,500 to 5,000	None

Table XI—Continued

Aircraft type	Fatigue package number	Structural detail	Safe-life based on a scatter factor of 4		Number of airplanes modified as of Jan. 1969	Total number of airplanes in fleet	Table IX median time to first failure in fleet		Range of life during which fatigue package was installed based on scatter factor 4 (hours)	Observed first failure time (hours)
			Test (hours)	Calculation (hours)			For inspected fleet (hours)	For total fleet (hours)		
P	I	1	---	3,100	2	2	---	7,250	1,500 to 3,000	None
		2	---	3,100			---	7,250		
		3	---	3,100			---	7,250		
		4	---	11,800			---	27,600		
		5	---	5,400			---	12,500		
		6	---	7,100	2	2	---	16,600	1,500 to 3,000	None
C	II	12	---	10,800	10	11	17,000	16,700	9,500 to 11,000	None
		13	---	11,100	10	11	17,500	17,200	9,500 to 11,000	None
D	II	12	---	11,300	2	10	26,400	17,800	9,500 to 11,000	None
		13	---	10,900	2	10	25,500	17,200	9,500 to 11,000	None
E	II	7	---	7,900	7	8	13,700	13,300	6,500 to 8,000	None
		9	7,900	---			13,700	13,300		
		11	8,300	---			14,400	14,000		
		12	---	10,000			17,400	16,800		
		13	---	10,300	7	8	17,900	17,300	6,500 to 8,000	None
F	II	12	---	11,300	4	6	22,400	20,500	9,500 to 11,000	None
		13	---	10,900	4	6	21,600	19,800	9,500 to 11,000	None

Table XI—Concluded

Aircraft type	Fatigue package number	Structural detail	Safe-life based on a scatter factor of 4		Number of airplanes modified as of Jan. 1969	Total number of airplanes in fleet	Table IX: median time to first failure in fleet		Range of life during which fatigue package was installed based on scatter factor≥4 (hours)	Observed first failure time (hours)
			Test (hours)	Calculation (hours)			For inspected fleet (hours)	For total fleet (hours)		
J	II	7	---	10,800	3	5	23,100	20,200	9,500 to 11,000	None
		9	---	10,800			23,100	20,200		
		11	---	11,300			24,200	21,200		
		12	---	11,600			24,800	21,700		
		13	---	12,000	3	5	25,600	22,500	9,500 to 11,000	None
M	II	7	---	7,900	2	3	18,500	16,900	6,500 to 8,000	None
		9	7,900	---			18,500	16,900		
		11	8,500	---			19,400	17,700		
		12	---	10,000			23,400	21,400		
		13	---	10,300	2	3	24,100	22,000	6,500 to 8,000	None
P	II	7	---	3,500	1	2	9,800	8,200	2,000 to 3,500	None
		9	---	3,500			9,800	8,200		
		11	---	3,700			10,400	8,700		
		12	---	6,900			19,300	16,100		
		13	---	5,700	1	2	16,000	13,300	2,000 to 3,500	None

Table XII. Comparison of Results Between Uncensored Fatigue Data and Data Censored for High-Time Outliers (Log-Normal Distribution)

	Size of groups (n specimens)	Log-normal model	
		Number of groups	$\hat{\sigma}'$ (log X)
MLE-uncensored	2	420	0.149
	3	328	0.181
	4	234	0.159
	5	145	0.208
	Weighted value of all groups	1,250	0.168
MLE-censored	2	420	0.149
	3	279	0.111
	4	193	0.108
	5	119	0.147
	Weighted value of all groups	1,121	0.135

Table XIII. Scatter Factors To Obtain Reliability $\bar{R}$ in the <u>Weakest</u> of a Fleet of Size N, When n Specimens Are Tested To Failure (Log-Normal Model)

NOTES: 1. Data based on log-normal model with known shape parameter (σ = 0.14) and with unknown scale parameter μ estimated at the 95% confidence level.

2. Scatter factor $\frac{10^{\hat{\mu}}}{\check{Z}_{\bar{R}}} = S = S_n \cdot S_{\bar{R}} \cdot S_{N_{\bar{R}}}$

Sample size n	S_n	Reliability $\bar{R}$	$S_{\bar{R}}$	Fleet size N	$S_{N_{\bar{R}}}$ $\bar{R}$ 0.500	$S_{N_{\bar{R}}}$ $\bar{R}$ 0.600	$S_{N_{\bar{R}}}$ $\bar{R}$ 0.750	$S_{N_{\bar{R}}}$ $\bar{R}$ 0.900	$S_{N_{\bar{R}}}$ $\bar{R}$ 0.950	$S_{N_{\bar{R}}}$ $\bar{R}$ 0.990
1	1.70	0.500 (median life)	1.00	1	1.00	1.00	1.00	1.00	1.00	1.00
2	1.45	0.600	1.09	3	1.30	1.27	1.24	1.19	1.16	1.13
3	1.36	0.750	1.24	10	1.62	1.56	1.49	1.39	1.35	1.28
4	1.30	0.900	1.51	20	1.80	1.72	1.64	1.51	1.45	1.36
5	1.27	0.950	1.70	50	2.03	1.95	1.82	1.67	1.57	1.48
10	1.18	0.990	2.12	100	2.24	2.11	1.97	1.77	1.70	1.56
∞	1	---	---	200	2.42	2.32	2.10	1.90	1.82	1.66
				500	2.64	2.50	2.31	2.05	1.94	1.77
				1,000	2.82	2.65	2.44	2.21	2.07	1.85
				10,000	3.45	3.24	2.96	2.62	2.45	2.18

$\hat{\mu}$ = MLE of log-normal scale (μ) = $1/n \sum_{i=1}^{n} \log Y_i$

$\check{Z}_{\bar{R}}$ = design or certifiable life

Table XIV Scatter Factors To Obtain Reliability $\bar{R}$ in the Second Weakest of a Fleet of Size N, When n Specimens Are Tested To Failure (Log-Normal Model)

NOTES: 1. Data based on log normal model with known shape parameter (σ = 0.14) and with unknown scale parameter μ estimated at the 95% confidence level.

2. Scatter factor $\frac{10^{\hat{\mu}}}{\tilde{Z}_{\bar{R}}}$ = S = $S_n \cdot S_{\bar{R}} \cdot S_{N_{\bar{R}}}$

Complete sample size n	S_n	Reliability $\bar{R}$	$S_{\bar{R}}$	Fleet size N	$S_{N_{\bar{R}}}$ $\bar{R}$ = 0.500	$S_{N_{\bar{R}}}$ $\bar{R}$ = 0.750	$S_{N_{\bar{R}}}$ $\bar{R}$ = 0.900	$S_{N_{\bar{R}}}$ $\bar{R}$ = 0.950
1	1.70	0.50	1.00	10	1.37	1.22	1.07	1.05
2	1.45	0.95	1.24	50	1.81	1.58	1.40	1.29
3	1.36	0.90	1.51	200	2.14	1.85	1.64	1.51
4	1.30	0.95	1.70	1,000	2.55	2.19	1.91	1.76
5	1.27	---	---	---	---	---	---	---
10	1.18	---	---	---	---	---	---	---
∞	1.00	---	---	---	---	---	---	---

$\hat{\mu}$ = MLE of log-normal scale (μ) = $\frac{1}{n} \sum_{i=1}^{n} \log Y_i$

$\tilde{Z}_{\bar{R}}$ = design or certifiable life

Table XV. Scatter Factors To Obtain Reliability $\bar{R}$ in the <u>Weakest</u> of a Fleet of Size N, When n Specimens Are Tested to Failure (No Failure Model Assumed)

NOTES: 1. Data based on the Tchebycheff Limit Theorem in lieu of an assumed failure model. The log-standard deviation σ is assumed to equal 0.14; the unknown log average η is estimated at a confidence level greater than 95%.

2. Scatter factor $\frac{10^{\bar{\eta}}}{\check{Z}_{\bar{R}}} = S = S_n \; S_R$

Sample size n_f	S_{n_f}	Fleet size N	Reliability $\bar{R}$				
1	4.30		0.50	0.75	0.90	0.95	0.99
2	2.80	1	1.58	1.91	2.76	4.3	25
3	2.30	10	3.6	6.8	20.00	90.0	$>10^4$
4	2.06	50	15.0	76.0	1,100	$>10^4$	$>10^4$
5	1.91						
10	1.58						
∞	1.00		Tabulated values are of S_R				

$\bar{\eta}$ = average of log lives of data

$\check{Z}_{\bar{R}}$ = safe life

APPENDIX I

MATHEMATICAL DERIVATIONS, THEOREMS, AND PROOFS REQUIRED FOR APPLICATION OF THE WEIBULL MLE

INTRODUCTION

This appendix discusses all nonobvious mathematical statements introduced in the text that pertain to maximum-likelihood estimation of Weibull population parameters. These include:

a) A derivation of the Weibull MLE for all samples.

b) Proof that the following statistics are independent of α and β, for all complete and some censored samples,

   1) $U = \hat{\alpha}/\alpha$
   2) $V = (\hat{\beta}/\beta)^{\hat{\alpha}}$
   3) $W = (\hat{\beta}/\beta)^{\alpha}$

c) A brief description of the computational procedure used to obtain the empirical marginal distributions of U and V.

d) Some remarks pertaining to the adequacy of the random-number generator used to generate independent exponential variates needed to initiate the above computational procedure.

e) A derivation of the theoretical distribution of W.

DERIVATIONS

Let X be a random variable with a Weibull distribution. The reliability of X then is

$$R(x) = \exp[-(x/\beta)^{\alpha}] \quad \text{for } x > 0 \tag{AI-1}$$

where $\alpha, \beta > 0$ are the two parameters of the distribution.

We assume that a number of components, say n, each with the same Weibull distribution of life are put on test. However, what is observed at each trial is the time the component fails or the time the test is terminated. Let Z be a random time at which the test is terminated for any reason other than failure of the component. Then what we observe is the event

$$[X = x] \cap [X < Z] \qquad \text{or} \qquad [Z = z] \cap [X \geq Z] \tag{AI-2}$$

We now state

Lemma 1: If $(Z_1,\ldots,Z_n)$ is a vector of nonnegative random variables, possibly dependent on $(X_1,\ldots,X_n)$, which are themselves independently and identically distributed nonnegative random variables with common

density function f and distribution F, then the likelihood of the event

$$\bigcap_{i=1}^{k} [X_i \le Z_i] [X_i = x_i] \bigcap_{i=k+1}^{n} [X_i > Z_i] [Z_i = z_i] \tag{AI-3}$$

where k ($\le n$) is the (random) number of failures observed, is of the form

$$C \prod_{i=1}^{k} f(x_i) \prod_{j=k+1}^{n} [1 - F(z_j)]$$

and the constant C depends on $(x_1,\dots,x_k)$ but not on F.

Proof: Let g be the joint density of $(Z_1,\dots,Z_n)$ given $X_1,\dots,X_n$. Then the probability of the event specified in Eq. (AI-3) is

$$\int_{\{z_i > x_i \;\; i=1,\dots,k\}} \cdot \cdot \cdot \int \prod_{i=1}^{k} f(x_i) \prod_{i=k+1}^{n} [1-F(z_i)] g(z_1,\dots,z_n | x_1,\dots,x_n)$$

$$dz_1,\dots,dz_k$$

which upon simplification shows that

$$C = \int_{\{z_i > x_i \;\; i=1,\dots,k\}} \cdot \cdot \cdot \int g(z_1,\dots,z_n | x_1,\dots,x_n) dz_1,\dots,dz_k \tag{AI-4}$$

and thus for an observed failure time $(x_1,\dots,x_k)$, C does not depend on F. ||

To simplify the notation in what follows we let $(t_1,\dots,t_k)$ denote the set of complete observations of X and $(t_{k+1},\dots,t_n)$ denote the set of censored tests (i.e. the set of observations of Z). Then from the lemma we see that the log-likelihood, except for some constant independent of α, β, is

$$L = \sum_{i=1}^{k} [\ln(\frac{\alpha}{\beta}) + (\alpha-1)\ln(\frac{t_i}{\beta}) - (\frac{t_i}{\beta})^{\alpha}] - \sum_{k+1}^{n} (\frac{t_i}{\beta})^{\alpha} \tag{AI-5}$$

and we then obtain

$$\frac{\partial L}{\partial \alpha} = \frac{k}{\alpha} + \sum_{i=1}^{k} \ln\left(\frac{t_i}{\beta}\right) - \sum_{1}^{n} \left(\frac{t_i}{\beta}\right)^{\alpha} \ln\left(\frac{t_i}{\beta}\right) \qquad \text{(AI-6)}$$

$$\frac{\partial L}{\partial \beta} = -k\,\frac{\alpha}{\beta} + \frac{\alpha}{\beta}\sum_{1}^{n} \left(\frac{t_i}{\beta}\right)^{\alpha} \qquad \text{(AI-7)}$$

Thus the two maximum-likelihood estimators $\hat{\alpha}$, $\check{\beta}$ of α and β when both parameters are unknown are defined by

$$\frac{1}{k} \sum_{i=1}^{n} \left(\frac{t_i}{\check{\beta}}\right)^{\hat{\alpha}} = 1 \qquad \text{(AI-8)}$$

and

$$\frac{k}{\hat{\alpha}} = \sum_{i=1}^{n} \left(\frac{t_i}{\check{\beta}}\right)^{\hat{\alpha}} \ln\left(\frac{t_i}{\check{\beta}}\right) - \sum_{1}^{k} \ln\left(\frac{t_i}{\check{\beta}}\right) \qquad \text{(AI-9)}$$

These results have been given previously by Cohen (13).

Let us define

$$y_i = \left(\frac{t_i}{\beta}\right)^{\alpha} \quad \text{for } i=1,\ldots,n$$

$$u = \frac{\hat{\alpha}}{\alpha}, \quad v = \left(\frac{\check{\beta}}{\beta}\right)^{\alpha}$$

then Eqs. (AI-8) and (AI-9) become, respectively--by using the fact that

$$\left(\frac{t_i}{\check{\beta}}\right)^{\hat{\alpha}} = \left(\frac{y_i}{v}\right)^{u}, \quad \left(\frac{t_i}{\check{\beta}}\right)^{\alpha} = \frac{y_i}{v}$$

and simplifying:

$$v = \left[\frac{1}{k} \sum_{i=1}^{n} y_i^{u}\right]^{\frac{1}{u}} \qquad \text{(AI-10)}$$

and

$$\frac{\sum_1^n y_i^u \ln y_i}{\sum_1^n y_i^u} - \frac{1}{u} = \frac{1}{k} \sum_{i=1}^{k} \ln y_i \qquad \text{(AI-11)}$$

For $i=1,\ldots,k$ we know that y_i is an independent observation from an exponential random variable with unit mean. Consider the condition:

$$(Y_{K+1},\ldots,Y_n) \mid (Y_1,\ldots,Y_K) \qquad \text{(AI-12)}$$

has a distribution independent of α and β, where K is the random number of uncensored items.

We can now state:

Theorem 1: A necessary and sufficient condition that U and V, as defined in Eqs. (AI-10) and (AI-11), have a distribution independent of α and β is that Eq. (AI-12) be true.

Proof: It is clear from Eqs. (AI-10) and (AI-11) that U and V are parameter free if $Y_1,\ldots,Y_n$ are, which is true iff condition (AI-12) is [illegible].

Note, for example, that condition (AI-12) is true if with probability one

$$K = k \text{ and } Z_{k+1} = \ldots = Z_n = X_{k,n} \qquad \text{(AI-13)}$$

where $x_{k,n}$ is the k^{th}-ordered observation out of n. This is merely the case of sampling censored at the k^{th} failure time.

Let us briefly consider the case when Eq. (AI-13) is true. Under this condition we can obtain the distribution of U and V by Monte-Carlo simulation methods:

Let $n \geq k$ be given positive integers. Let $y_{(1)},\ldots,y_{(k)}$ be the first k-ordered observation from n independent machine-generated exponential variates each with unit mean. Solve for μ in the equation $\phi(u) = 0$, where

$$\zeta(u) = \frac{\sum_{1}^{k} y_{(i)}^{u} \ln y_{(i)} + (n-k)y_{(k)}^{u} \ln y_{(k)}}{\sum_{1}^{k} y_{(i)}^{u} + (n-k)y_{(k)}^{u}} - \frac{1}{u} - \frac{1}{k} \sum_{1}^{k} \ln y_{(i)}$$

Now compute

$$v = \left[\frac{1}{k} \left(\sum_{1}^{k} y_{(i)}^{u} + (n-k)y_{(k)}^{u} \right)\right]^{\frac{1}{u}}$$

Repeat this procedure m times for independent samples of y's, and so obtain a sample of size m of (U,V). The sample size m can be made sufficiently large to determine the distribution of U,V to a degree of accuracy determined by the machine procedure that generates the pseudorandom numbers.

The random-number generators used in the simulation studies presented here are of the type called composite congruential generators. These "second generation" methods appear to be better; that is, they satisfy more stringent statistical tests of randomness than those of the simple congruential generators used previously. In the particular method adopted here, three generators are mixed for the IBM 360, each of which will produce a full period of residues relatively prime to the modulus 2^{32} (consequently, these mixed generators will produce 2^{30} distinct random numbers before repeating). This method is presented in detail and discussed by Marsaglia and Bray (29). To obtain our exponential variates with unit mean, we merely take the negative of the natural logarithm of the uniform variates generated by the mixed congruential method.

We now consider the sampling distribution of $\hat{\beta}$:

Theorem 2: If α is known, the maximum-likelihood estimate of β, call it $\hat{\beta}$, is

$$\hat{\beta} = \left[\frac{1}{k} \sum_{1}^{n} t_{i}^{\alpha}\right]^{\frac{1}{\alpha}}$$

and

$$w = \left(\frac{\hat{\beta}}{\beta}\right)^{\alpha}$$

has a distribution independent of α and β if condition (AI-12) is true. Moreover, in this case the distribution is the same as that of

$$W = \frac{1}{k} \sum_{1}^{n} Y_i$$

Proof: The proof is immediate.

In the special case when Eq. (AI-13) is satisfied, then

$$W = \frac{1}{k} \sum_{i=1}^{k} Y_{(i)} + (n-k)Y_{(k)}$$

where the $Y_{(i)}$ are the first k-ordered observations from independent exponential variates with unit mean. Thus:

$$W = \frac{1}{k} \sum_{j=1}^{k} (n-j+1)[Y_{(j)}-Y_{(j-1)}]$$

which by known results (e.g. Ref. 30, p.18) is the sum of k independent exponential variates with unit mean. By the well-known fact (e.g. Ref. 31) that two times an exponential variate with unit mean is a chi-square variate with two degrees of freedom, and the reproducing property of chi-square variables under convolution (Ref. 30, p. 10), there follows the result that $2kW$ has a chi-square distribution with $2k$ degrees of freedom.

APPENDIX II

LIST OF SALIENT FEATURES AND UNBIASED POINT ESTIMATES OF POPULATION PARAMETERS OF COLLECTED FATIGUE DATA

1. TABULATED RESULTS

The salient features of all the collected fatigue performance data, including the estimated population parameters, are tabulated in this appendix. The estimates of the scale parameters were included to complete the description of the data only, and no further use is made of the generated values.

An 11-digit description number is provided to catalog the variables of specimen thickness, material, grain direction, type of structure, type of specimen, finish, type of loading, and type of failure. A code is provided on the following page to facilitate usage of the tabulated data descriptions.

Also listed on the output are the test sample size and the number of samples tested to failure. Two additional columns, labeled "size used for MLE, log-normal and Weibull," are given. These columns demonstrate the number of specimens used for estimating the shape parameter after the high-time outliers have been censored from the sample. It can be seen from the tabulated results that the high-time outlier afflicts only a minority of the data and that a sample censored for the Weibull model is not necessarily censored for the log-normal model.

The initial two shape parameters are the unbiased point estimates for the log-normal and Weibull models using the MLE on data that had been censored for high-time outliers, and the last column is the unbiased point estimate of the Weibull shape parameter given by the two-ordered-statistic estimator.

Finally, a complete listing of the data references is presented, and corresponds with the REF column of the computer printout.

2. LIST OF REFERENCES

The following reference sources are those identified in the REF column of the computer printout tabulations in Appendixes II and III:

(1) W.J. Crichlow, A.J. McCulloch, L. Young, and H.A. Melcon: An Engineering Evaluation of Methods for the Prediction of Fatigue Life in Airframe Structures, Technical Report No. ASD-TR-61-434, May 1962

(2) A. Hartman and G.C. Dunn: A Comparative Investigation on the Fatigue Strength of Fluctuating Tension of Several Types of Riveted Lap Joints, a Series of Bolted and Some Series of Glued Lap Joints of 24S-T Alclad, NLL Report M.1857, 1952

(3) H.F. Hardrath, E.C. Utley, and D.E. Guthrie: Rotating Beam Fatigue Tests of Notched and Unnotched 7075-T6 Aluminum Alloy Specimens Under Stresses of Constant and Varying Amplitudes, NASA TN D-210, December 1959

(4) H.F. Hardrath and E.C. Utley: An Experimental Investigation of the Behavior of 24S-T4 Aluminum Alloy Subjected to Repeated Stresses of Constant and Varying Amplitudes, NACA TN 2798, October 1952

(5) W. Klaassen and A. Hartman: The Fatigue Diagram for Fluctuating Tension of Single Lap Joints of Clad 24S-T and 75S-T Aluminum Alloy With Two Rows of 17S Rivets, NLL Report M.1980, January 1955

(6) A. Hartman and F.A. Jacobs: Research on the Static and Fatigue Strengths of Bonded and Riveted Single-Lap Joints in Clad 2024 and 7075 Aluminum Alloy at Room and Elevated Temperatures, NLL-TN M.2041, September 1957

(7) A. Hartman and P. de Rijk: The Effect on the Static and Fatigue Properties of Riveted Light Alloy Lap Joints of Reinforcing the Critical Section With Thin Adhesive Bonded Sheets, NLL-TN M.2047, March 1958

(8) F.A. Jacobs and A. Hartman: The Effect of Sheet Thickness and Overlap on the Fatigue Strength at Repeated Tension of Redux Bonded 75S-T Clad Simple Lap Joints, NLL Report M-1969, October 1954

(9) R.B. Heywood: The Influence of Pre-Loading on the Fatigue Life of Aircraft Components and Structures, ARC TN No. 232, June 1955

(10) Z.W. Birnbaum and S.C. Saunders: A Statistical Theory of Life Length of Materials, BAC-D2-1325, September 1956

(11) D.A. Paul and D.Y. Wang: Fatigue Behavior of 2014-T6, 7075-T6, and 7079-T6 Aluminum Alloy Regular Hand Forgings, WADC Technical Report 59-591, January 1960

(12) S. Kelsey and J.B. Spooner: Direct Stress Fatigue Tests on Redux Bonded and Riveted Double Strap Joints in 10 S.W.G. Aluminum Alloy Sheet, ARC. Technical Report CP No. 353, December 1955

(13) E.C. Naumann: Evaluation of the Influence of Load Randomization and of Ground-Air-Ground Cycles on Fatigue Life, NASA TN D-1584, October 1964

(14) E.C. Naumann: Fatigue Under Random Loads, NASA TN D-2629, February 1965

(15) P.L. Corbin and E.C. Naumann: Influence of Programming Techniques and of Varying Limit Load Factors on Maneuver Load Fatigue Test Results, NASA TN D-3149, January 1966

(16) H.J. Grover, S.M. Bishop, and L.R. Jackson: Fatigue Strength of Aircraft Materials: Axial Load Fatigue Tests on Notched Sheet Specimens of 2024-T3 and 7075-T6 Aluminum Alloy and of SAE 4130 Steel With Stress Concentration Factors of 2.0 and 4.0, NACA TN 2389, July 1951

(17) J. Schijve and F.A. Jacobs: Fatigue Tests on Notched and Unnotched Clad 24S-T Sheet Specimens To Verify the Cumulative Damage Hypotheses, NLL Report M.1982, April 1955

(18) A.J. McCulloch, M.A. Melcon, W.J. Crichlow, H.W. Foster, and R. Rebman: Investigation of the Representation of Aircraft Service Loadings in Fatigue Tests, ASD-TR-61-435, January 1962

(19) W. Weibull: Scatter in Fatigue Life of 24S-T Alclad Specimens With Drilled Holes, SAAB TN 32, May 1955

(20) J. Schijve and F.A. Jacobs: Program-Fatigue Tests on Notched Light Alloy Specimens of 2024 and 7075 Material, NLL Technical Report M.2070, 1960

(21) I.E. Wilks and D.M. Howard: Effect of Mean Stress on the Fatigue Life of Alclad 24S-T3 and Alclad 75S-T6 Aluminum Alloy, WADC Technical Report 53-40, June 1953

(22) I. Smith, D.M. Howard, and F.C. Smith: Cumulative Fatigue Damage of Axially Loaded Alclad 75S-T6 and Alclad 24S-T3 Aluminum Alloy Sheet, NACA Technical Note 3293, September 1955

(23) C.B. Landers and H.F. Hardrath: Results of Axial-Load Fatigue Tests on Electropolished 2024-T3 and 7075-T6 Aluminum-Alloy-Sheet Specimens With Central Holes, NACA Technical Note 3631, March 1956

(24) H.J. Grover, S.M. Bishop, and L.R. Jackson: Fatigue Strengths of Aircraft Materials: Axial-Load Fatigue Tests on Unnotched Sheet Specimens of 24S-T3 and 75S-T6 Aluminum Alloys and of SAE 4130 Steel, NACA Technical Note 2324, March 1951

(25) W. Weibull: Static Strength and Fatigue Properties of Unnotched Circular 75S-T Specimens Subjected to Repeated Tensile Loading, FFA Report 68, June 1956

(26) W. Weibull: A New Method for the Statistical Treatment of Fatigue Data, SAAB Technical Note 30, May 1954

(27) S.R. Swanson: An Investigation of the Fatigue of Aluminum Alloy Due to Random Loading, UTIA Report No. 84, September 1963

(28) A.M. Freudenthal and R.A. Heller: On Stress Interaction in Fatigue and a Cumulative Damage Rule, Part I, 2024 Aluminum and SAE 4340 Steel Alloy, WADC Technical Report 58-69, Part I, June 1958

(29) A.M. Freudenthal and R.A. Heller: On Stress Interaction in Fatigue and a Cumulative Damage Rule, Part II, 7075 Aluminum Alloy, WADC Technical Report 58-69, Part II, January 1960

(30) R.A. Heller: Influence of Residual Stresses on Random Fatigue Life, In Bending, of Notched 7075 Aluminum Specimens, ASD-TDR 62-1075, December 1962

(31) I.G. Hendrickson and R.W. Walter: Compilation of Structural Test Data for Reliability Research Program, Boeing document D6-14085, February 1966

(32) P.J. Mitchell: The Laboratory Fatigue Performance of Aircraft Structural Parts, Vol. I, Boeing document D6-23298TN (unreleased)

(33) R.J. Soderlund: Fatigue Test of W.S. 392 Production Improvement and Retro-Fix (C/KC135), Boeing document T6-3403, July 1964

(34) L. Piepho: Fatigue Tests of Lower Surface Splice at W.S. 360, Stringers 12 and 13, Boeing document T-29051, December 1956

(35) J.P. Ruane: Component Fatigue Test W.S. 396 and W.B.L. 315, Boeing document T6-2560, October 1963

(36) S.L. Engstrom: Fatigue and Static Tests of Longitudinal and Circumferential Fuselage Skin Splices, Boeing document T-29015, August 1955

(37) I.N. Vaughan: Static and Fatigue Tests of Various Stringer-to-Frame Attachments, Boeing document T-29023, January 1958

(38) J.E. Chavey: Fatigue Life Comparison of the Modified and Original Doubler Configurations at the Lower Wing Surface (W.S. 392), Boeing document T6-2579, January 1964

(39) P.A. Clawson: Sonic Excitation Tests of Wing Trailing-Edge Surface Panels, Boeing document T6-1031, December 1956

(40) D.J. Allmaras and A.F. Laier: Loads for KC-135 Wing Fatigue Test, Boeing document D6-1884, April 1960

(41) Boeing Test Progress Report No. T-29025, Section 1, January 1955

(42) Boeing Test Progress Report No. T-29025, Section 2, March 1955

(43) Boeing Test Progress Report (KC-135), March 29, 1955

(44) Boeing Test Progress Report (KC-135), July 6, 1955

(45) Boeing Test Progress Report (KC-135), August 31, 1955

(46) Boeing Test Progress Report (KC-135), November 22, 1955

(47) Boeing Test Progress Report (KC-135), August 8, 1955

(48) Boeing Test Progress Report (KC-135), June 4, 1955

(49) Boeing Test Progress Report (KC-135A), April 11, 1955

(50) Boeing Test Progress Report (B-52) No. STMP-57-366, January 14, 1957

(51) Boeing Test Progress Report (B-52) No. STMP-57-410, March 25, 1957

(52) Boeing Test Progress Report (B-52) No. STMP-57-460, March 25, 1957

(53) Boeing Test Progress Report (B-52) No. STMP-56-71, May 9, 1956

(54) Boeing Test Progress Report (B-52) No. STMP-57-405, March 13, 1957

(55) Boeing Test Progress Report (B-52) No. STMP-57-422, April 12, 1957

(56) Boeing Test Progress Report (B-52) No. STMP-57-433, May 29, 1957

(57) Boeing Test Progress Report (KC-135) No. T-29040, September 23, 1955

(58) W.A. Burnham: Corrosion Fatigue Tests of KC-135 Fuselage Joints, Boeing document T6-1122, 1958

(59) H.E. Parish: Fatigue Test Results and Analysis of 42 Piston Provost Wings, ARC reports and memoranda No. 3474, April 1965

(60) L.R. Foster Jr., and R.E. Whaley: Fatigue Investigation of Full-Scale Transport-Airplane Wings, NASA TN D-547, October 1960

(61) A.O. Payne: Random and Programmed Load Sequence Fatigue Tests on 24ST Aluminum Alloy Wings, ARL Report SM.244, September 1956

(62) M.J. McGuigan, Jr., D.F. Bryan, and R.E. Whaley: Fatigue Investigation of Full-Scale Transport-Airplane Wings, NACA TN 3190, March 1954

(63) J.Y. Mann and C.A. Patching: Fatigue Tests on Mustang Wings and Notched Aluminum Alloy Specimens Under Random Gust Loading, With and Without Ground to Air Cycles of Loading, ARL SM Note 268, June 1961

(64) R.A. Cari and T.J. Wegeng: "Investigations Concerning the Fatigue of Aircraft Structures," ASTM Proceedings, 1954

(65) G.S. Jost: The Fatigue of 24S-T Aluminum Alloy Wings Under Asymmetrical Specturm Loading, ARL Structures and Materials Report 295, February 1964

(66) R.B. Heywood: The Strength of Lugs in Fatigue, RAE Technical Note Structures 182, January 1956

(67) J.H. Rondeel, R. Kruithof, and F.J. Plantema: Comparative Fatigue Tests With 24S-T Alclad Riveted and Bonded Stiffened Panels, NLL Report S.416, December 1952

(68) M.S. Rosenfeld: Aircraft Structural Fatigue Research in the Navy, ASTM Special Technical Publication No. 338, October 1962

(69) C.B. Castle and J.F. Ward: Fatigue Investigation of Full-Scale Wing Panels of 7075 Aluminum Alloy, NASA Technical Note D-635, April 1951

(70) K.D. Raithby: Fatigue Tests on Typical Two-Spar Light Alloy Structures (Meteor 4 Tailplanes) Under Reversed Loading, RAE Report No. Structures 108, May 1951

(71) H. Yeomans: Programmed Loading Fatigue Tests on a Bolted Joint, RAE TN No. Structures 327, March 1963

(72) C.R. Smith: Linear Strain Theory and the Smith Method for Predicting Fatigue Life of Structures for Spectrum-Type Loading, ARL 64-55, April 1964

(73) J. Schijve and F.A. Jacobs: Research on Cumulative Damage in Fatigue of Riveted Aluminum Alloy Joints, NLL Report M.1999, January 1956

DATA CODING SYSTEM

X X X X X X X X X X X

SPECIMEN THICKNESS: (three digits)

Thickness of Minimum or Fractured Material or Specimen Diameter (10^{-3} in.)

000 - Thickness not known or variable

MATERIALS: (two digits)

01 - 2024-T3 Bare
02 - 2024-T3 Clad
03 - 2024-T3 EXTR
04 - 2024-T4 Bare
05 - 2024-T4 Clad
06 - 2024-T4 EXTR
08 - 6061-T6
10 - 7075-T6 Bare

11 - 7075-T6 Clad

12 - 7075-T6 EXTR
13 - 7075-T6 Die-forged
14 - 7076-T6 Bare
15 - 7076-T6 Clad
16 - 7076-T6 EXTR
17 - 7079-T6 Bare
18 - 7079-T6 Clad
19 - 7079-T6 EXTR
20 - 7178-T6 Bare

21 - 7178-T6 Clad
22 - 7178-T6 EXTR
23 - 7076-T61
24 - Al-Ni-Bronze
25 - Berylliym copper 25
26 - 6 Al-4Va titanium alloy
27 - DTD 687A Al alloy
28 - 2024-0 (annealed)
29 - 1100-
30 - D.T.D. 363A
31 - D.T.D. 364B EXTR
32 - D.T.D. 683 (RR. 77) EXTR
33 - D.T.D. 546B Clad
34 - D.T.D. 610 Clad

40 - SAE 4350 (H.T. 300 ksi)

41 - 4130 Steel
43 - 4340 Steel
44 - 4405 Steel (Aom)
45 - SAE 1045
46 - SAE 1017 (or ASTM-285)
47 - SAE 1018
48 - SAE 1050
50 - Composed of more than one kind of material

51 - 2024 skin & 2024 stiffener
52 - 2024 skin & 2024 stiffener & other additional materials
53 - 2024 skin & 7075 stiffener
54 - 2024 skin & 7075 stiffener & other additional materials
55 - 7075 skin & 7075 stiffener
56 - 7075 skin & 7075 stiffener & other additional materials
58 - 7178 skin & 7178 stiffener

59 - 7178 skin & 7178 stiffener & other additional materials
87 - 2014-T6 Hand-forged
88 - 7075-T6 Hand-forged
89 - 7079-T6 Hand-forged

GRAIN DIRECTION:

0 - Not known
6 - Diagonal
7 - Other directions
8 - Longitudinal
9 - Short transverse

TYPE OF STRUCTURE:

0 - Lugs
1 - Butt joint
2 - Lap joint
3 - Double shear
4 - Scarf joint
5 - Monolithic unnotched
6 - Monolithic notched
7 - Partial load transfer
8 - Structural components and full-scale structures
9 - Service airplanes

TYPE OF SPECIMEN:

0 - Open holes
1 - Riveted
2 - Spotwelded
3 - Bolted
4 - Riveted & bonded
5 - Edge-notched
6 - Pin-connected
7 - Riveted & bolted
8 - Bonded
9 - Others

FINISH:

0 - Normal
1 - Shot-peened
2 - Chem-milled
3 - Corroded
4 - Machine milled & polished
5 - Chem-milled & shot-peened
6 - Chem-milled & chem-polished
7 - Different etchants
8 - Others
9 - Heat-treated

TYPE OF LOADING:

0 - Axial (comp.-comp.)
1 - Axial (other types)
2 - Bending flexural
3 - Bending rotating beam
4 - Torsion
5 - Spectrum (random)
6 - Spectrum (decreasing stress amplitude)
7 - Spectrum (increasing)
8 - Spectrum (up & down stress
9 - Sonic fatigue

TESTING PECULIARITIES:

0 - Normal complete failure
1 - First crack
2 - Special type
5 - Data revised

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR LNM	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE -BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
1	1	04010860010	5	5	5	5	2144	6200	11860	6172	.2768	7963	2.0190	1.0507
2	1	04010860010	5	5	5	5	3300	3354	6377	4609	.1308	5293	3.3966	5.1704
3	1	04010860010	5	5	5	5	2765	3130	8091	4589	.1968	5521	2.2711	8.0181
4	1	04010860010	5	5	5	5	3272	3906	5200	4269	.0820	4629	6.0075	5.3170
5	1	04010860010	5	5	5	5	1290	2445	5173	2842	.2260	3593	2.2602	1.7663
6	1	04010860010	5	5	5	5	4331	4500	6300	5044	.0655	5413	6.0923	23.1670
7	1	04010860010	5	5	5	4	10800	37800	132000	37627	.3563	36753	2.6075	.8335
8	1	04010860010	5	5	5	5	10900	12600	41600	20430	.2413	26152	1.9665	7.2178
9	1	04010860010	5	5	5	5	9000	10800	18800	12748	.1420	14321	2.9496	6.1198
10	1	04010860010	5	5	5	5	7995	8722	11295	9788	.0652	10425	9.1878	12.4108
11	1	04010860010	5	5	5	5	12600	12600	16203	14310	.0546	15125	8.6754	VERY HIGH
12	1	04010860010	5	5	5	5	3600	5403	7053	5736	.1217	6188	5.2042	2.7517
13	1	04010860010	5	5	5	5	12600	12600	25200	15968	.1264	18266	2.9665	VERY HIGH
14	1	04010860010	5	5	5	5	7200	36300	265563	68997	.6409	132274	.7666	.6712
15	1	04010860010	5	5	5	5	27000	27540	55800	40491	.1578	47223	3.3814	55.3613
16	1	04010860010	5	5	5	4	23600	32600	64600	39457	.2087	46306	4.1773	3.6246
17	1	04010860010	5	5	3	3	13660	14430	76743	16352	.0580	15700	8.5567	23.1311
18	1	04010860010	5	5	5	4	27600	53303	63603	65045	.2179	78583	3.0463	1.3537
19	1	04010860010	5	5	5	5	195560	164900	239400	206217	.0365	215074	9.3697	152.9527
20	1	04010860010	5	4	5	4	176400	180300	[illegible]	242493	.1698	292733	2.1553	55.3363
22	1	04010860010	5	5	5	5	3600	4293	7200	5033	.1273	5767	3.4491	5.4225
23	1	04010860010	5	5	5	5	1860	2530	6150	3456	.2325	2594	5.3392	1.7733
24	1	04010860010	5	5	5	5	1471	2125	3170	2436	.1341	2755	5.3583	2.6317
25	1	04010860010	5	5	3	3	88200	93200	1236000	120396	.1227	110375	4.0141	VERY HIGH
26	1	04010860010	2	2	2	2	12014	14956	14956	13360	.0452	14050	6.6597	6.6116
27	1	04010860010	5	5	5	5	1200	1900	4673	2357	.2246	2063	1.3627	3.3517
28	1	04010860010	5	5	5	5	25240	26903	37400	31445	.0675	33731	5.5594	17.1167
29	1	04010860010	5	5	5	5	9000	9600	27000	12528	.1544	11050	6.2167	17.2476
30	1	04010860010	5	5	5	5	6300	6450	15040	8105	.1554	9074	2.2501	67.4158
31	1	04010860010	5	5	4	4	25700	35700	576000	57874	.2524	61590	1.3753	3.1261
32	1	04010860010	5	5	5	5	6150	6100	8620	7339	.0670	7441	7.5504	45.3005
33	1	04010860010	5	5	5	5	16600	16740	34209	22114	.1696	26376	2.5606	7.6136
34	1	04010860010	5	5	5	4	22000	174600	2136000	272405	.3046	295117	1.5755	1.6136
36	1	[illegible]	5	5	5	5	2440	4176	7350	5645	.1653	6482	4.3768	1.6525
37	1	[illegible]	5	5	4	4	[illegible]	101500	361700	96651	.1506	100436	4.2455	[illegible]
38	1	[illegible]	5	5	5	5	1	2450	[illegible]	3074	.2076	3747	2.5596	2.3761
39	1	[illegible]	5	5	5	5	15700	29903	64800	38244	.1881	46741	2.2975	.3555
40	1	[illegible]	5	5	4	4	516	3600	22544	4733	.5041	4524	1.4415	[illegible]
41	1	[illegible]	6	6	5	6	25200	32400	45000	37745	.1005	41330	6.2762	[illegible]
42	1	[illegible]	6	6	6	6	3342	3465	4330	3731	.0484	3629	8.6941	[illegible]

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS • UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR MLE LNM	SIZE FOR MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
43	1	04010460010	6	6	6	6	9900	10400	14700	12421	.0733	13379	6.6296	15.0123
44	3	30012465830	10	10	5	5	70000	76300	3318000	85978	.0500	91041	14.3531	12.8115
45	3	30012465830	10	10	9	8	92000	94000	11600000	233604	.3479	215514	2.9037	7.7165
46	3	30012465830	10	10	10	10	7100	7400	9900	8482	.0490	8938	9.8669	25.4595
47	3	30012465830	10	10	10	10	15400	15900	19200	16733	.0287	17307	13.1077	32.9753
48	3	30012455830	10	10	10	9	60000	64000	269000	61855	.2351	56678	6.3503	11.0565
49	3	30012455830	10	10	10	9	121000	171000	18439000	635406	.6252	658342	1.1527	1.3662
50	3	30012465830	10	10	10	10	61000	192300	763000	341054	.3943	493554	1.5853	.7363
51	3	30012865830	10	10	10	10	17000	17000	41009	28001	.1429	32356	3.8922	VERY HIGH
52	3	30012465830	10	10	7	6	29000	31000	689000	53822	.1978	43279	4.5067	15.7182
53	3	30012465830	10	10	10	10	224000	253000	842000	460235	.2251	584007	2.2716	8.6543
54	3	30012465830	10	10	10	10	739000	943000	1348000	1034149	.0929	1146545	6.9095	21.0363
55	13	09010465010	5	5	5	5	13430	15090	20570	15890	.0681	17138	5.3765	9.5736
56	16	09010465010	3	3	3	3	4000	5600	5500	4916	.0777	5251	7.4792	6.0532
57	16	09010865010	2	2	2	2	11400	12300	12300	11696	.0158	11889	20.1935	27.0768
58	16	09010865010	2	2	2	2	10300	11500	11500	10724	.0429	11101	9.8100	9.9193
59	16	09010465010	2	2	2	2	13300	14600	14600	13935	.0286	14260	14.7019	14.8692
60	16	09010460010	2	2	2	2	2600	2700	2700	2650	.0116	2682	27.4390	36.7376
61	16	09010465010	3	3	3	3	32000	39000	41007	37125	.0569	38999	9.5535	6.1488
62	16	09010465010	2	2	2	2	39500	45800	45800	42534	.0455	44119	9.2650	9.3579
63	16	09010465010	2	2	2	2	82500	140000	140000	107471	.1624	122488	2.5926	2.6716
64	16	09010465010	2	2	2	2	10500	10700	10700	10600	.0058	10663	56.8355	71.4716
65	16	09010465010	2	2	2	2	7800	10000	10000	8832	.0763	9391	5.5182	5.5795
66	23	09110860010	2	2	2	2	16000	19000	19000	17436	.0528	18193	7.9782	8.0467
67	23	09110860010	2	2	2	2	39000	68000	68000	51498	.1707	59084	2.4662	2.4935
68	23	09110860010	2	2	2	2	81000	107000	107000	93097	.0855	99732	4.9251	4.9799
69	23	09110860010	2	2	2	2	136000	303300	300000	201990	.2430	245644	1.7330	1.7529
70	23	09110860010	2	2	2	2	9000	9100	9100	9050	.0034	9082	93.5221	125.4586
71	23	09110860010	2	2	2	2	41000	67000	67000	52412	.1508	59181	2.7917	2.8227
72	23	09110860010	2	2	2	2	91000	96000	96000	93467	.0164	95072	19.3652	25.91
73	23	09110860010	2	2	2	2	221000	719000	719000	398671	.3623	533672	1.1622	1.1751
74	23	09110860010	2	2	2	2	17000	27000	27000	21424	.1421	24021	2.9637	2.9764
75	23	09110860010	2	2	2	2	41000	55000	55000	47487	.0902	51065	4.6673	4.7191
76	23	09110860010	2	2	2	2	158000	229000	228000	195714	.0938	211069	4.4897	4.5395
77	23	09110860010	2	2	2	2	8000	9300	9000	8485	.0362	8736	11.6606	11.7699
78	23	09110860010	2	2	2	2	84000	125000	125000	102470	.1221	113055	3.4492	3.4876
79	23	09110860010	2	2	2	2	14000	16000	16000	14967	.0410	15469	10.2677	19.3618
80	23	09110860010	2	2	2	2	25000	64000	64000	40000	.2887	50469	1.4586	1.6748
81	23	09110860010	2	2	2	2	40000	82000	82000	57271	.2205	68399	1.9100	1.9312
82	23	09110860010	2	2	2	2	117000	140000	140000	127984	.0551	133793	7.6396	7.7766

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS • UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR MLE LNM	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
83	23	09110860010	2	2	2	2	18000	21000	21000	19442	.0473	20198	8.8943	8.9931
84	23	09110860010	2	2	2	2	39000	42000	42000	39950	.0307	40951	13.6992	13.8516
85	23	09110860010	2	2	2	2	339000	592000	592000	447321	.1721	513830	2.4463	2.4735
86	23	09110860010	2	2	2	2	15000	43000	43000	25397	.3234	32953	1.3019	1.3163
87	23	09110860010	2	2	2	2	32000	37000	37000	34409	.0446	35667	9.4437	9.5407
88	23	09110860010	2	2	2	2	66000	174000	124000	90465	.1937	105735	2.1741	2.1903
89	23	09110960010	2	2	2	2	15000	18000	18000	16971	.0362	17472	11.6406	11.7690
90	23	09110860010	2	2	2	2	43000	53000	53000	47739	.0642	50273	6.5572	6.6301
91	23	09110860010	2	2	2	2	153000	177000	177000	164563	.0448	170602	9.4094	9.9139
92	11	10088865410	3	3	3	3	120900	295300	587300	275152	.3425	376632	1.3491	1.3593
93	11	10088865410	2	2	2	2	23700	26400	26400	25014	.0331	25690	12.7081	12.8493
94	11	10098865410	2	2	2	2	10300	12000	12000	11118	.0449	11546	8.9751	9.0760
95	11	10088965410	2	2	2	2	370700	1272000	1272000	686681	.3786	931512	1.1120	1.1246
96	11	10088765410	2	2	2	2	123400	287300	287300	188289	.2595	232059	1.6224	1.6404
97	47	05611860210	6	6	6	6	31000	34000	49000	41513	.1173	47180	3.5591	11.8425
98	57	06311860010	6	6	5	6	34000	36000	46000	39430	.0520	41649	8.6223	19.1396
99	21	03211060010	4	4	4	4	2800	3190	3580	3266	.0502	3422	10.7215	8.8765
100	21	03211060010	4	4	4	4	3800	4350	4800	4378	.0446	4560	12.1762	8.5129
101	21	03211060010	4	4	4	4	5550	5570	6860	6084	.0464	6373	9.6345	119.9921
102	21	03211060010	4	4	4	4	9680	10780	13520	11651	.0689	12454	7.1267	10.6919
103	21	03211060010	4	4	4	4	23890	30010	36190	29850	.0741	32057	6.3057	5.0455
104	21	03211060010	4	4	4	4	4180	6260	6710	5821	.0967	6317	6.9496	2.8691
1[illegible]	21	03211060010	4	4	4	4	9680	9810	12350	10393	.0502	10978	7.2027	66.2591
106	21	03211960010	4	4	4	4	11470	11900	15590	13340	.0673	14259	6.9739	31.2660
107	21	03211060010	4	4	4	4	26310	26460	31200	28128	.0540	29633	9.2099	13.5786
108	21	03211060010	5	5	5	5	50770	62120	77570	68801	.0506	72475	9.0897	50.7796
109	21	03211060010	4	4	4	4	8990	9410	12910	10505	.0720	11307	5.8403	25.2021
110	21	03211060010	4	4	4	4	12380	12410	23340	15620	.1308	17905	3.0442	475.4623
111	21	03211060010	4	4	4	4	27910	28240	34980	30875	.0489	32421	9.2117	97.8183
112	21	03211060010	5	5	5	5	58210	64570	69820	71420	.0727	77050	5.9411	10.7590
113	21	03211060010	4	4	4	4	28780	36410	43740	36314	.0755	39001	6.4688	4.8933
114	21	03211050010	4	4	4	4	42610	72790	95550	71685	.1588	82562	3.6830	2.1987
115	21	03211060010	4	4	4	4	109620	206790	286220	206075	.1936	244910	3.0206	1.8131
116	21	03211060010	4	4	4	4	111710	118690	171200	139104	.0956	152933	4.9903	18.9967
117	21	03211060010	4	4	4	4	195150	363160	541950	377990	.2075	456270	2.7154	1.8678
118	23	09110860010	2	2	2	2	250000	398000	398000	315436	.1428	353881	2.9486	2.9811
119	23	03111860010	2	2	2	2	12000	12100	12100	12050	.0026	12082	124.4032	147.0676
120	23	03110860010	2	2	2	2	17000	46000	46000	27964	.3057	35779	1.3776	1.3977
121	23	09111860010	2	2	2	2	30000	48000	48000	45166	.2513	55298	1.6755	1.6961
122	23	09110860010	2	2	2	2	164000	293000	293000	2[illegible]3434	.1676	246557	2.5130	2.4413

TABLE [illegible] SALIENT FEATURES OF DATA GROUPS [illegible] TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

[illegible]	[illegible]	SAMPLE SIZE	NUMBER FAILED	SIZE USED FOR MLE LNM	SIZE USED FOR MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	175000	242000	242000	205791	.0996	222969	4.2297	[illegible]
[illegible]	[illegible]	[illegible]	2	[illegible]	2	12000	13000	13000	12490	.0246	12817	12.9636	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	40000	62000	62000	49600	.1346	55501	3.1205	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	85000	97000	1052000	94673	.0366	93817	10.3821	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	253000	381000	575000	376183	.1871	447521	7.1956	[illegible]
[illegible]	[illegible]	[illegible]	2	[illegible]	2	13000	16000	16000	14422	.0638	15152	6.6031	[illegible]
[illegible]	[illegible]	[illegible]	2	[illegible]	2	25000	26100	26100	26050	.0012	26082	267.7235	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	59000	70000	70000	68993	.0089	69633	35.7149	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	53000	287000	5251000	217162	.4207	195629	.9042	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	138000	411000	411000	238155	.3352	311949	1.2563	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	33000	39000	39000	35875	.0513	37388	8.2073	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	154000	212000	212000	180688	.0982	195551	4.2895	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	23000	26000	26000	24454	.0377	25207	11.1030	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	85000	95000	95000	89861	.0342	92367	12.3260	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	51000	254000	254000	124475	.4381	177133	.9612	[illegible]
[illegible]	[illegible]	[illegible]	2	[illegible]	2	11000	12000	12000	11489	.0267	11739	15.7573	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	21000	51000	51000	32726	.2725	40757	1.5452	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	182000	239000	239000	208562	.0837	223100	5.0322	[illegible]
141	[illegible]	[illegible]	[illegible]	[illegible]	2	21000	26000	26000	23367	.0656	24634	6.6196	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	38000	83000	83000	56160	.2399	68131	1.7549	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	20000	25000	25000	22361	.0685	23629	6.1443	[illegible]
144	[illegible]	[illegible]	[illegible]	[illegible]	2	70000	90000	90000	79373	.0772	84463	5.4556	[illegible]
[illegible]	[illegible]	[illegible]	2	2	2	23000	33000	33000	27550	.1109	30123	3.7970	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	57000	233000	233000	115243	.4324	163249	.9738	[illegible]
147	[illegible]	[illegible]	2	2	2	10000	11000	11000	10488	.0293	10738	14.3091	[illegible]
[illegible]	[illegible]	[illegible]	2	[illegible]	2	28000	54000	54000	38894	.2017	45743	2.0870	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	84000	176000	176000	121589	.2272	145997	1.8536	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	601	640	5055	1415	.3835	1339	1.6956	[illegible]
261	[illegible]	[illegible]	5	[illegible]	5	901	1081	2760	1436	.1873	1758	2.0941	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	5	[illegible]	786	1509	2621	1704	.2113	2074	2.6517	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	661	915	1101	928	.0887	1005	6.7495	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	1215	1519	2843	1890	.1491	2199	3.1050	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	[illegible]	610	873	705	.1025	777	5.1990	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	331	342	537	403	.0865	442	6.6019	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	150	250	350	256	.1440	293	3.8721	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	171	175	315	205	.1108	232	3.2159	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	343	450	664	500	.1112	557	4.4800	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	36	110	183	114	.2886	145	2.3336	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	142	215	360	233	.1493	270	3.0969	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	670	741	1016	852	.0787	920	6.6144	[illegible]

TABLE [illegible] SALIENT FEATURES OF DATA GROUPS [illegible] ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM NO.	[illegible]	SAMPLE SIZE (N)	NUMBER FAILED	SIZE USED LOG-NORMAL	SIZE USED WEIBULL	FIRST FAILURE (TIME 1)	SECOND FAILURE (TIME 2)	LAST FAILURE (TIME R)	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6	[illegible]	531	1001	680	.1229	775	5.3996	58.6850
[illegible]	[illegible]	[illegible]	5	[illegible]	6	601	665	1203	742	.1726	929	2.8519	11.7293
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6	676	743	1862	956	.2244	1202	1.9797	2.4822
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6	135	228	296	249	.0765	269	6.4027	7.1367
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6	366	433	846	552	.1465	644	2.8413	15.5322
[illegible]	[illegible]	[illegible]	6	6	5	665	672	813	686	.0896	779	7.0472	3.4213
[illegible]	[illegible]	[illegible]	6	5	6	1265	1550	2460	1650	.1176	2075	4.2760	3.9515
[illegible]	[illegible]	[illegible]	6	6	6	100	130	250	194	.2233	242	2.1706	4.2526
261	[illegible]	[illegible]	5	[illegible]	5	90	169	230	162	.1563	187	3.7233	1.9392
[illegible]	[illegible]	[illegible]	5	[illegible]	[illegible]	147	263	503	306	.2066	373	2.5526	1.9183
263	[illegible]	[illegible]	5	[illegible]	[illegible]	450	453	1855	692	.2563	512	6.9506	VERY HIGH
266	[illegible]	5	5	5	5	156	168	203	175	.0396	183	10.4176	15.0553
[illegible]	[illegible]	[illegible]	5	5	5	125	184	242	186	.1061	205	5.0598	2.8458
[illegible]	[illegible]	[illegible]	6	5	5	383	475	708	508	.1224	578	3.5542	10.7725
[illegible]	[illegible]	5	[illegible]	5	6	360	433	1033	512	.1768	442	10.1464	6.2795
[illegible]	[illegible]	5	5	6	6	360	478	1387	560	.1260	572	4.0076	3.9356
[illegible]	[illegible]	5	5	6	[illegible]	780	1031	3300	1501	.2591	1091	4.7610	3.9391
[illegible]	[illegible]	5	5	5	5	493	728	1021	741	.1139	827	4.2178	2.8623
271	[illegible]	5	6	5	5	450	605	861	651	.1073	723	4.5986	5.7696
[illegible]	[illegible]	[illegible]	6	5	5	500	900	2060	1211	.2555	1542	2.1619	1.8987
274	[illegible]	5	5	5	5	772	1391	1766	1330	.2277	1500	4.5326	1.8949
276	[illegible]	[illegible]	5	[illegible]	5	685	502	543	511	.0189	527	23.3513	32.3856
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1332	1356	1396	1344	.0055	1352	57.9339	77.6306
[illegible]	[illegible]	6	5	5	[illegible]	2049500	1979800	8109720	4722936	.2267	5853382	2.3465	1.7633
[illegible]	[illegible]	10	10	[illegible]	6	160000	375000	22918000	1280808	.3619	1010975	1.7959	10.7532
[illegible]	[illegible]	[illegible]	10	10	10	11364000	11765000	32273000	17264702	.1657	20791438	2.5892	27.8835
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7020000	150412000	38975585	.6151	70345264	.9952	1.0553
[illegible]	[illegible]	[illegible]	5	5	5	[illegible]	23602000	599517000	**4461895	.9656	**4497815	.5741	.9728
[illegible]	[illegible]	[illegible]	10	10	10	762000	1051000	6274000	1539357	.3769	2277889	1.2380	.7176
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1293000	1290000	71645000	2774715	.2243	2608829	2.7722	194.5402
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1380000	4938000	268102000	*35137392	.7716	76629323	.6912	.8315
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11703300	108325000	488848000	**4843281	.5231	*9351393	1.2660	.4733
[illegible]	[illegible]	[illegible]	10	[illegible]	10	735000	1116000	2449000	1356819	.1363	1604738	3.1849	2.5228
[illegible]	[illegible]	10	9	[illegible]	5	1658000	1658000	33570000	2800042	.1642	3125576	2.9819	175.2140
[illegible]	[illegible]	10	6	[illegible]	[illegible]	3611700	3682000	122585000	*18309423	.4521	23141526	1.2116	54.1106
[illegible]	[illegible]	[illegible]	7	7	7	1758000	2965000	505327000	**9897745	1.3053	*7190779	.3655	14.5583
[illegible]	[illegible]	[illegible]	[illegible]	2	2	292300	1079400	1079400	3646847	1.2320	13414109	.2066	.9373
337	[illegible]	2	2	2	[illegible]	1186700	1771600	1771600	1451172	.1225	1601690	3.4360	3.4762
[illegible]	[illegible]	[illegible]	6	6	6	1185350	1261840	1411570	1279323	.0322	1322660	12.4862	24.7170
[illegible]	[illegible]	6	6	6	2	1962590	2503000	6717590	3769086	.2678	2357397	5.9126	4.9625

[illegible] DATA GROUPS
[illegible] ESTIMATED [illegible] PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	[illegible]	NUMBER 1/	FAILED	SETS USED FOR MLE LN	WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(INF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE -BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
400	[illegible]	[illegible]	[illegible]	[illegible]	9	79000	81000	130000	100526	.0696	108227	6.6035	42.3997
401	[illegible]	[illegible]	5	[illegible]	4	54100	232000	1579000	412470	.4388	103382	2.1503	.9735
402	[illegible]	4	4	4	4	271000	271000	346000	293745	.0500	309870	7.5466	VERY HIGH
403	[illegible]	[illegible]	5	[illegible]	5	396000	397000	667000	470657	.1367	539009	3.5610	4.1901
404	[illegible]	[illegible]	4	4	4	76300	92300	130000	90935	.0618	95895	9.0422	5.2953
405	[illegible]	[illegible]	5	[illegible]	5	152000	331000	609000	428131	.1558	497925	3.3664	4.7725
406	[illegible]	[illegible]	4	4	4	542000	278000	1050000	864739	.1321	965996	5.1568	1.9929
407	[illegible]	15	15	15	15	154620	175500	280115	211978	.0587	226516	7.0060	25.8779
408	[illegible]	6	6	5	6	47340	99170	142123	115692	.0630	123592	6.9666	60.0575
409	[illegible]	[illegible]	6	5	6	115111	115563	140900	120687	.0347	125724	9.7361	280.9394
410	[illegible]	12	12	12	12	97380	99170	142120	118163	.0494	124764	8.8426	57.3238
411	[illegible]	25	25	25	25	12376	12410	20842	15897	.0709	17257	6.3802	371.9902
412	[illegible]	6	6	6	6	42290	52365	63494	53897	.0604	57132	8.5765	5.1228
413	[illegible]	5	5	5	6	46392	46092	56207	48930	.0368	50962	10.5534	29.1093
414	[illegible]	7	7	7	7	39423	40103	57709	48379	.0707	51986	7.0815	25.2146
415	[illegible]	6	5	6	6	40501	46125	52345	46722	.0364	48451	12.8851	8.4130
416	[illegible]	[illegible]	6	6	6	30926	36556	59997	41986	.1067	46907	4.4069	9.8518
417	[illegible]	31	31	31	31	30926	36556	63494	47845	.0719	51589	7.4119	9.1536
418	[illegible]	6	5	5	6	136529	115598	142289	126368	.0435	131905	11.7318	17.3361
419	[illegible]	5	5	6	6	40501	46125	52346	46723	.0344	48451	12.8834	8.4130
420	[illegible]	5	5	6	6	321977	371651	460595	395471	.0541	417252	9.1292	7.6245
421	[illegible]	5	5	5	5	73209	87657	136866	92072	.0590	97673	8.8136	5.1515
422	[illegible]	5	6	6	6	16344	19074	22868	20282	.0472	21239	10.9695	9.2383
423	[illegible]	[illegible]	5	5	6	159976	157049	229632	189207	.0589	198503	6.9174	25.2853
424	[illegible]	[illegible]	5	6	6	35530	35530	49726	37920	.0347	39457	10.9217	VERY HIGH
425	[illegible]	[illegible]	5	5	6	32470	33660	40766	36514	.0413	38139	10.8357	30.3923
426	[illegible]	5	5	5	6	451075	480100	582111	504585	.0383	526236	10.2616	17.5619
427	[illegible]	6	6	6	6	97658	99567	119000	104519	.0490	109789	10.0125	8.4361
428	[illegible]	6	6	6	6	478873	478873	763099	605456	.0830	657802	6.0122	VERY HIGH
429	[illegible]	6	6	6	6	100576	100576	140023	109715	.0616	117687	5.9893	VERY HIGH
430	[illegible]	5	6	5	6	76923	84780	101310	90281	.0424	94109	12.0519	11.2681
431	[illegible]	6	5	6	6	12376	12410	19890	15189	.0938	16811	4.5470	398.7373
432	[illegible]	7	7	7	7	13498	13974	19788	16450	.0703	17726	6.6806	31.1353
433	[illegible]	6	6	6	6	14722	14756	17631	15224	.0313	15807	10.3380	474.2182
434	[illegible]	[illegible]	5	5	6	13960	14212	20842	16693	.0819	18201	5.5642	56.6091
435	[illegible]	6	6	6	6	54083	54083	69911	59445	.0457	62509	8.7746	VERY HIGH
436	[illegible]	6	6	6	6	47065	49578	64653	54854	.0580	58402	7.3357	21.0303
437	[illegible]	6	6	6	6	54681	59805	72748	64629	.0481	67804	10.6429	12.2127
438	[illegible]	7	7	7	7	32174	38221	60666	41637	.0873	45998	4.2409	6.2653
439	15 09010465080	7	7	7	7	46978	46978	79069	55631	.0840	61191	4.5049	VERY HIGH

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR LGN	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
[illegible]	[illegible]	6	6	6	6	17393	20357	23412	20573	.0417	21637	11.4066	6.9519
441	[illegible]	5	6	5	6	29511	32462	40457	34213	.0472	35989	8.7298	11.4773
[illegible]	[illegible]	8	8	8	8	167705	196295	191054	166405	.0372	173459	11.0701	18.4977
[illegible]	[illegible]	6	6	6	6	192131	215964	285456	231646	.0585	246672	6.9965	9.5358
444	[illegible]	[illegible]	6	5	6	152298	158592	228126	185887	.0774	201468	6.1237	27.0134
[illegible]	[illegible]	5	5	5	6	96148	95579	191390	127552	.1323	146880	3.3013	72.5171
[illegible]	[illegible]	6	5	6	6	103347	102741	135515	109838	.0495	116300	7.1123	46.3983
[illegible]	[illegible]	6	6	6	6	1453000	1470000	1936000	1649896	.0626	1756097	7.2036	98.9277
[illegible]	[illegible]	5	5	5	5	458000	1030000	2103000	1231238	.2721	1587275	2.0520	1.3767
[illegible]	[illegible]	5	5	[illegible]	5	3178000	3777000	5070000	4165255	.0830	4526909	5.9085	6.4613
[illegible]	[illegible]		6	6	5	4553000	5386000	10056000	6004853	.1315	6965924	2.6966	6.6405
[illegible]	[illegible]	6	6	6	6	170000	233000	326000	228461	.0967	293715	4.1444	5.7311
[illegible]	[illegible]	5	5	5	5	211600	278000	305300	256967	.0673	273051	6.8704	14.3987
[illegible]	[illegible]	7	7	7	7	239000	248000	652000	358682	.1526	424763	2.6147	29.1911
[illegible]	[illegible]	[illegible]	8	8	8	165000	153000	498000	247584	.1891	304384	2.2764	19.8916
[illegible]	[illegible]	6	6	5	6	415000	461300	928000	578830	.1635	688670	2.6025	10.3608
[illegible]	[illegible]	5	5	6	6	226000	257000	319000	273434	.0587	289513	8.6744	8.1184
[illegible]	[illegible]	6	6	6	6	39200	52200	95300	56563	.1265	65261	2.8627	3.8195
[illegible]	[illegible]	[illegible]	5	[illegible]	6	61300	55500	68002	57464	.0767	61578	7.9368	3.7017
[illegible]	[illegible]	10	10	10	10	[illegible]	239000	359000	270353	.0605	290067	6.2984	22.3510
[illegible]	[illegible]	5	5	5	5	[illegible]	740300	1020000	805641	.1116	894116	4.9156	2.9740
[illegible]	[illegible]	6	6	6	6	157300	158300	259000	192975	.0976	213648	4.1467	16.9929
[illegible]	[illegible]	[illegible]	6	[illegible]	5	119000	136000	187000	143705	.0733	155602	5.2389	8.7745
[illegible]	[illegible]	[illegible]	6	6	6	464000	496100	783000	550408	.0845	606102	4.2517	10.7477
[illegible]	[illegible]	6	6	6	6	744000	775300	1309000	977922	.1039	1091766	4.2746	30.8496
[illegible]	[illegible]	7	7	7	7	17600	22100	44000	26693	.1230	30592	3.1065	4.8357
[illegible]	[illegible]	[illegible]	6	[illegible]	6	9700	12200	19300	13612	.1090	15237	3.8904	3.9136
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	8200	12300	17400	12368	.1171	13863	3.9622	2.7517
[illegible]	[illegible]	[illegible]	5	[illegible]	5	3100	9800	13500	10865	.0699	11678	5.9907	15.0553
[illegible]	[illegible]	[illegible]	5	[illegible]	5	[illegible]	571000	1646000	901590	.2395	1145011	2.0181	4.8559
[illegible]	[illegible]	[illegible]	6	[illegible]	6	[illegible]	[illegible]	136000	107238	.1062	119401	4.5029	93.1613
[illegible]	[illegible]	[illegible]	6	[illegible]	6	[illegible]	[illegible]	141000	142000	.0879	155960	4.5896	131.0963
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	358000	250095	.0537	275694	5.1289	8.7441
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21681000	[illegible]	.3567	2401935	1.2081	1.0143
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.2167	[illegible]	2.1111	182.9645
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2037666	.1560	2468565	2.0418	5.2201
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1595157	.1287	1990750	4.5286	2.4135
[illegible]	[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.0443	[illegible]	10.1491	11.2825
[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	457831	.5447	1378061	1.1898	.5133
[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6252650	.2516	5361458	2.1900	1.7201

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS • UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR MLE LNM	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE -BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
597	1	30012865830	5	5	4	5	67600000	64368000	337566000	10343009	.4200	3282879	1.1625	21.5096
598	1	30012865830	16	16	16	16	1556600	1568837	2650000	1910319	.0554	2035771	7.3216	16.6352
599	1	30012865830	10	10	10	10	763350	865880	1906720	1152524	.1170	1312521	3.5646	6.9053
600	1	04010860010	5	5	5	5	100800	135000	385200	200301	.2403	255733	1.9244	3.0192
601	1	04010850010	5	5	4	4	37440	91800	1700000	97517	.2334	103637	2.5900	1.2440
602	1	04010860010	5	5	3	3	484200	525600	2719600	656902	.1049	610385	4.7432	13.5993
603	1	04010860010	5	5	3	3	9540	12600	52200	13843	.1021	13023	5.4625	4.8104
604	1	04011360010	5	5	5	5	14580	40140	148500	64682	.4358	100417	1.2964	1.1017
605	1	04010850010	5	5	4	5	185000	248000	691700	381423	.2524	491861	1.9806	3.8070
607	1	04010860010	5	5	5	4	1660	2215	9011	3437	.2855	3261	2.3394	3.8682
608	1	04010860010	5	5	5	5	28800	45000	73800	53988	.1754	61497	3.3426	2.5303
609	1	04010860010	5	5	5	4	28800	36300	98200	42716	.1868	38222	6.3298	9.0003
610	1	04010860010	5	5	5	5	185400	352800	3216600	722483	.4884	1200246	.8845	1.7341
611	1	04010860010	5	5	3	3	48600	55800	888480	118632	.3254	94295	1.5183	8.0761
612	21	03211060010	4	4	4	4	410720	416320	525560	417708	.0954	456416	5.1857	3.9430
649	1	04010860010	5	5	5	5	163000	189000	3601000	780505	.6123	1436247	.8057	7.5308
650	1	30012865830	5	5	5	5	75300	76300	369000	141342	.2285	107485	6.8491	85.0326
651	1	30012865830	10	10	10	8	179000	208000	929000	346301	.2367	321039	3.3083	7.0169
652	1	30012865830	10	10	6	8	319000	374000	3864000	624684	.1578	644890	3.8851	6.6238
653	1	30012865830	11	11	11	10	490000	491300	3643000	1105793	.2523	1205531	2.4735	514.2459
654	1	30012865830	4	4	4	3	520000	574000	1293000	695419	.1817	582910	14.4634	11.4470
655	1	30012865830	5	4	3	3	529000	1333303	2778000	1010307	.1651	939641	3.5501	1.7522
656	11	10084955410	2	2	2	2	72000	161000	161000	107466	.2471	131376	1.7037	1.7227
657	11	10084955410	2	2	2	2	42300	58600	58400	49702	.0991	53829	4.2510	4.2982
658	11	10084955410	2	2	2	2	58900	1269400	1269400	273437	.9429	584333	.4465	.4515
659	11	10084955410	2	2	2	2	79700	121400	121400	98365	.1292	109154	3.2581	3.2343
660	11	10084955410	2	2	2	2	54100	142303	142000	87648	.2964	111274	1.4208	1.4366
661	11	10084955410	2	2	2	2	19100	28100	28100	23167	.1186	25488	3.5512	3.5907
662	11	10084955410	2	2	2	2	8800	14000	14000	11100	.1426	12450	2.9529	2.9857
663	57	06311855020	7	7	7	7	25000	26300	31000	28494	.0348	29470	16.9154	27.5124
664	57	05511855223	6	6	6	6	32000	52000	90000	50794	.1013	55256	7.3480	2.2532
665	22	05611055010	4	4	4	4	11970	12620	14920	13028	.0412	13613	9.1333	21.7614
666	22	05611055010	4	4	4	4	47980	51740	58470	53017	.0362	54967	12.3196	15.2522
667	22	05611055010	4	4	4	4	14880	14820	16150	15285	.0206	15604	21.3977	70.4805
668	22	05611055010	4	4	4	4	45150	46460	53410	48043	.0320	49719	11.6937	40.2332
669	22	05611055010	4	4	4	4	11970	12620	14920	13028	.0412	13613	9.1333	21.7614
670	22	05611055010	4	4	4	4	47980	51740	58470	53017	.0362	54967	12.3196	15.2522
671	22	05611055010	4	4	4	4	13890	14520	15740	14816	.0236	15162	19.5439	25.9419
672	22	05611055010	4	4	4	4	41550	43570	47940	45133	.0308	46493	15.1526	24.2405
673	22	05611055010	2	2	2	2	15770	17563	17560	16641	.0330	17089	12.7524	12.8741

ITEM	RAF DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE USED FOR MLE LNM	SIZE USED FOR MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
674	22 06411055010	2	2	2	2	51480	53300	53300	52302	.0107	52965	29.8060	39.9015
675	22 06411055010	4	4	4	4	15520	16290	16450	16164	.0101	16334	63.7696	27.3980
676	22 06411055010	4	4	4	4	43590	50580	54790	49794	.0416	51740	12.4879	7.7371
677	22 06411055010	4	4	4	4	12560	12870	13060	13224	.0204	13491	23.3781	47.1961
678	22 06411055010	4	4	4	4	41670	52160	54200	50719	.0439	52653	14.9415	6.4773
679	22 06411055010	5	5	5	5	12630	14120	17010	15294	.0598	16079	10.0006	10.0049
680	22 06411055010	5	5	5	5	39680	41453	50290	47089	.0698	50708	5.0776	25.5561
681	22 06411055010	4	4	4	4	13720	15140	17220	15377	.0407	16009	10.7723	11.6042
682	22 06411055010	4	4	4	4	53280	56730	59610	57026	.0225	58234	23.5192	20.6719
683	22 06411055010	5	5	5	5	12000	15193	17980	15141	.0637	16093	7.0200	4.7333
684	22 06411055010	5	5	5	5	47950	54090	57370	53982	.0302	55435	20.6735	9.3170
685	22 06411055010	4	4	4	4	11950	12510	14040	13237	.0425	13814	10.3670	25.1267
686	22 06411055010	4	4	4	4	44770	48500	56010	49312	.0405	51442	9.6905	14.3795
687	22 06411055010	4	4	4	4	2810	2820	3660	3156	.0586	3346	7.7193	323.9297
688	22 06411055010	4	4	4	4	50730	53090	68910	59697	.0709	64002	6.7796	25.7333
689	22 06411055010	5	5	5	5	2610	2810	3730	2992	.0584	3192	6.2783	15.1111
690	22 06411055010	4	4	4	4	35960	42060	55270	44689	.0794	48335	9.6475	7.3442
691	22 06411055010	4	4	4	4	5170	5290	6120	5582	.0346	5779	12.7511	54.6576
692	22 06411055010	5	5	5	5	60580	65970	86565	71134	.0609	75076	6.7904	13.0899
693	22 06411055010	4	4	4	4	3050	3600	4360	3759	.0702	4016	7.3403	6.9400
694	22 06411055010	4	4	4	4	59030	60085	74020	64020	.0469	67331	7.9421	64.9599
695	22 06411055010	4	4	4	4	2970	3480	3730	3423	.0430	3556	13.3038	7.2615
696	22 06411055010	4	4	4	4	54130	57800	60030	58206	.0232	59455	23.6710	17.5415
697	22 06411055010	4	4	4	4	2020	3245	3660	3247	.0466	3391	10.0206	8.1973
698	22 06411055010	4	4	4	4	59540	59020	68250	62062	.0282	64712	14.6931	245.2691
699	22 06411055010	4	4	4	4	3020	3470	3910	3472	.0462	3629	10.1879	8.2047
700	22 06411055010	4	4	4	4	53700	63450	74530	65709	.0609	70016	7.9591	6.0972
701	22 06411055010	4	4	4	4	1960	1970	2200	2060	.0246	2112	17.0531	226.1176
702	22 06411055010	4	4	4	4	53280	56740	62765	57645	.0301	59416	14.2061	21.2033
703	22 06411055010	4	4	4	4	1965	2065	2390	2145	.0357	2225	11.3360	19.4129
704	22 06411055010	4	4	4	4	43450	43010	52055	47064	.0391	48943	11.4660	139.4611
705	22 06411055010	4	4	4	4	2390	2690	2930	2719	.0468	2822	13.5940	9.7319
706	22 06411055010	4	4	4	4	46240	48500	55390	50047	.0370	52721	12.8892	24.1140
707	22 06411055010	4	4	4	4	3790	3860	4370	4042	.0290	4162	15.1006	62.0773
708	22 06411055010	4	4	4	4	59900	74770	77590	71402	.0513	74461	12.9104	5.2213
709	22 06411055010	4	4	4	4	38270	40600	54600	45042	.0706	48369	6.1720	18.0427
710	22 06411055010	4	4	4	4	58090	72730	75645	72767	.0206	74335	21.9110	17.4595
711	22 06411055010	3	3	3	3	50258	60490	65060	58264	.0578	61300	8.6937	6.5642
712	22 06411055010	4	4	4	4	53400	54090	62320	56744	.0388	58592	13.0261	95.1110
713	22 06411055010	4	4	4	4	669250	856610	973500	848496	.0724	905097	7.9901	4.6621

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE USED FOR MLE LNM	SIZE USED FOR MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
714	22 06411055010	6	6	6	6	50930	68370	85910	70714	.0621	75449	6.3422	9.9082
715	22 06411055010	6	6	6	6	53200	65120	78670	68967	.0423	72089	9.3246	30.6586
716	22 06411055010	6	6	6	6	51690	54200	66800	56706	.0490	59775	7.5689	24.2685
717	22 06411055010	6	6	6	6	51830	59140	64630	59467	.0429	61807	12.9899	8.7217
718	22 06411055010	6	6	6	6	57110	59160	60550	57905	.0308	59438	21.6727	9.8680
719	22 06411055010	6	6	6	6	41330	44020	55200	46966	.0549	49695	7.4786	18.2493
720	22 06411055010	6	6	6	6	49110	55680	60920	55853	.0405	57967	11.2232	9.1649
721	22 06411055010	6	6	6	6	54080	54610	56980	55256	.0089	55[illegible]68	49.7254	117.9921
722	22 06411055010	4	6	6	6	52620	55400	55780	54837	.0120	55526	36.7784	22.3515
723	22 06411055010	6	6	6	6	46090	51060	61970	53013	.0597	55979	7.8282	11.2801
724	22 03211055010	6	6	6	6	37270	38600	44270	40597	.0353	42038	13.1119	32.8184
725	22 03211055010	6	6	6	6	32890	34070	35240	34072	.0123	34508	36.0669	32.6461
726	22 03211055010	6	6	6	6	205250	355240	795750	421791	.2497	533089	2.0271	2.1165
727	22 03211055010	5	5	5	5	27940	42430	57040	44513	.1297	50007	4.4951	2.6709
728	22 03211055010	6	6	6	6	26760	30390	35400	31342	.0954	32970	9.3760	9.0462
729	22 03211055010	6	6	6	6	378510	496770	534740	463005	.1003	504067	6.6740	2.7825
730	22 03211055010	6	6	6	6	20850	27940	32190	27065	.0888	30157	6.5128	3.9316
731	22 03211055010	6	6	6	6	408630	430030	498950	446973	.0371	463931	11.0271	22.9439
732	22 03211055010	6	6	6	6	30710	37800	41640	37324	.0591	39328	9.9811	5.5398
733	22 03211055010	4	4	4	6	19150	27070	28860	25475	.0834	27340	8.0075	3.3246
734	22 03211055010	6	6	6	6	441170	456380	591950	491685	.0571	522297	6.6439	33.9493
735	22 06411055010	6	6	6	6	28150	29550	31350	29915	.0206	30560	21.4770	23.7086
736	22 06411055010	6	6	6	6	26570	26590	33390	28158	.0494	29717	7.2927	1529.3178
737	22 06411055010	6	6	6	6	25330	26290	28943	26845	.0244	27594	16.3716	30.9342
738	22 06411055010	6	6	6	6	31470	33500	37380	34080	.0309	35174	13.2928	18.4085
739	22 06411055010	6	6	6	6	27270	30220	33390	30288	.0358	31365	12.6508	11.2029
740	22 06411055010	6	6	6	6	29650	33490	34040	32630	.0279	33408	24.1798	9.6689
741	22 06411055010	6	6	6	6	19460	21980	32580	24901	.0990	27397	6.3880	9.6499
742	22 06411055010	6	6	6	6	39400	41950	43210	41911	.0189	42739	23.4069	10.3492
743	22 06411055010	2	2	2	2	38530	38730	38730	38630	.0016	38694	198.9386	267.7622
744	22 06411055010	2	2	2	2	38530	39440	39440	38982	.0072	39273	64.3383	59.3871
745	22 06411055010	6	6	6	6	34700	35360	41725	37030	.0367	38507	10.3416	111.6919
746	22 06411055010	6	6	6	6	37960	38010	64940	40861	.0374	42618	12.7505	874.2082
747	22 06411055010	6	6	6	6	40160	40320	49140	43145	.0410	45094	9.6977	289.4078
748	22 06411055010	6	6	6	6	28170	31720	36700	32787	.0514	34423	9.8619	9.6953
749	22 06411055010	6	6	6	6	18230	19450	21250	19761	.0282	20310	16.6641	17.7641
750	22 06411055010	5	5	5	5	18820	21883	26130	22846	.0578	24180	8.6396	7.4059
751	22 06411055010	6	6	6	6	19950	22600	30620	25052	.0867	27263	5.5231	9.2264
752	22 06411055010	6	6	6	6	22910	23340	25480	23878	.0201	24382	21.9427	61.8833
753	22 06411055010	5	5	5	5	15800	16730	21990	18988	.0634	20206	8.1382	19.5077

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR MLE LNM	USED WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
754	22 0661105S010	6	6	5	5	21880	22170	29190	25903	.0645	27577	8.4136	84.7396
755	22 0661105S010	6	6	6	6	20640	21990	31940	23490	.0855	26211	6.2765	18.1626
756	22 0661105S010	6	6	6	6	14940	17450	21340	18761	.0465	19666	9.2551	38.7947
757	22 0661105S010	6	6	6	6	17940	18140	20440	18939	.0764	19458	15.8141	103.7946
758	22 0661105S010	6	6	6	6	12420	12620	15230	13647	.0441	14280	10.3400	72.0341
759	22 0661105S010	6	6	6	6	11500	15220	18910	15125	.0894	16464	5.4054	4.1059
760	22 0661105S010	6	6	6	6	22820	24220	28720	24977	.0427	26139	8.0688	19.3265
761	22 0661105S010	6	6	6	6	22100	24610	30400	26746	.0631	27902	7.6431	10.6970
762	22 0661105S010	6	6	6	6	21640	22045	22940	22164	.0107	22410	41.3756	62.0594
763	22 0661105S010	6	6	6	6	17760	21143	21930	20320	.0481	21166	13.7677	5.6626
764	22 0661105S010	6	6	6	6	20930	23050	25370	22986	.0321	23717	16.0592	11.9268
765	22 0661105S010	6	6	6	6	19960	20950	25970	22824	.0562	24122	8.4183	23.7713
766	22 0661105S010	6	6	6	6	20550	20750	24110	21538	.0328	22327	11.0116	118.8118
767	22 0661105S010	6	6	6	6	29125	29220	29540	29346	.0030	29478	145.1981	353.3641
768	22 0661105S010	6	6	5	6	29610	29900	35785	31723	.0379	33018	10.2124	118.0678
769	22 0661105S010	6	6	6	6	37685	38770	42700	39621	.0240	40675	16.4541	34..403
770	22 0661105S010	6	6	6	6	26540	30983	32600	29171	.0527	30584	10.5670	5.6531
771	22 0661105S010	6	6	6	6	27665	32630	34950	32294	.0493	33738	12.0299	6.9249
772	22 0661105S010	6	6	6	6	32850	37820	38210	36669	.0319	37660	21.8657	8.1678
773	22 0661105S010	6	6	6	6	37570	37685	37810	37741	.0009	37775	913.2520	2890.4375
774	22 0661105S010	6	6	6	6	30040	37530	40240	36137	.0553	37939	10.6840	5.1692
775	22 0661105S010	6	6	6	6	47390	52283	55570	51943	.0305	53410	17.4772	11.0361
776	22 0661105S010	6	6	6	6	40650	40659	40685	40611	.0012	40660	377.2536	733.3097
777	22 0661105S010	6	6	6	6	730100	753080	820090	764368	.0216	781709	20.4265	42.6722
778	22 0661105S010	6	6	6	6	699630	739433	799700	766444	.0239	765126	18.5326	20.5473
779	22 0661105S010	6	6	6	6	520030	540330	670330	588019	.0536	619976	8.6318	30.0502
780	22 0661105S010	6	6	6	6	493020	533370	629773	537151	.0496	566076	7.7510	56.6809
781	22 0661105S010	3	3	3	3	374300	410470	560263	443101	.0900	484209	4.3852	14.9040
782	22 0661105S010	3	3	3	3	497000	489510	497700	491352	.0049	493906	82.2533	236.6174
783	22 0661105S010	6	6	6	6	159660	324360	1074860	533697	.3616	753928	1.5063	1.5731
784	22 0661105S010	6	6	6	6	522370	523570	525080	523779	.0009	524293	467.1313	501.4968
785	22 0661105S010	6	6	6	6	518565	602120	1005260	666497	.1211	760373	3.0245	10.3331
786	22 0661105S010	6	6	6	6	57[illegible]600	589960	594680	587783	.0058	591339	75.9671	50.3029
787	22 0661105S010	6	6	6	6	435140	580900	616665	553102	.0703	587148	9.4017	3.9930
788	[illegible]	6	6	6	6	470160	549623	585220	563527	.0380	562170	15.7813	8.4133
789	[illegible]	6	6	6	6	490160	472160	512150	466251	.0457	483814	11.9822	6.9529
790	[illegible]	6	6	6	6	487330	459723	569450	490469	.0468	516721	8.2562	33.0395
791	[illegible]	6	6	6	6	154410	230680	202960	168451	.0598	198087	11.7604	4.2897
792	[illegible]	6	6	6	6	165470	187430	197600	191066	.0119	197444	37.0281	115.6287
793	[illegible]	6	6	6	6	153710	183360	150920	178132	.0317	183326	17.0729	9.7313

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	FEF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR MLE LNM	USED WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE -BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
794	22	06411055010	6	6	6	6	158070	169050	179680	170638	.0248	174610	21.3957	17.1350
795	22	06411055010	[illegible]	6	6	6	153260	152123	186140	169101	.0304	174595	12.8148	64.1995
796	22	06411055010	6	6	6	6	143870	168880	198920	173364	.0614	183661	8.3094	7.1796
797	22	06411055010	6	6	6	6	713210	955990	1114830	951249	.0870	1026126	7.0257	3.4027
798	22	03211055010	3	3	3	3	393160	419993	462320	426416	.0325	440028	12.6235	23.8893
799	22	03211055010	6	6	6	6	196530	226820	228220	207209	.0812	221710	8.6794	3.1025
800	22	03211055010	6	6	6	6	223110	251750	298370	261008	.0546	275107	8.7631	9.5281
801	22	03211055010	6	6	6	6	85440	92690	95950	91640	.0214	93699	20.6105	14.1287
802	22	03211055010	6	6	6	6	134500	135610	142150	137666	.0107	139208	41.1272	140.8097
803	22	03211055010	6	6	6	6	83080	87110	153870	102937	.1261	117403	3.0647	13.6754
804	22	03211055010	6	6	6	6	125960	139260	147030	139756	.0299	143571	19.1139	12.4443
805	22	03211055010	6	6	6	6	35410	78510	89410	67444	.1880	79055	3.5799	1.6452
806	22	03211055010	6	6	6	6	129210	132310	136140	132787	.0094	134093	46.8030	48.5362
807	22	03211055010	8	8	8	8	715780	815120	1362480	974483	.0852	1068573	6.9526	8.2197
808	22	03211055010	6	6	6	6	95920	185790	218600	166047	.1613	190757	3.9920	1.7406
809	22	06411055010	6	6	6	6	29960	37460	49735	39792	.0967	43632	5.1271	5.1631
810	22	03211055010	3	3	3	3	400670	459330	574900	472892	.0793	510304	5.2470	8.8704
811	22	06411055010	6	6	6	6	2660	3030	3850	3159	.0667	3382	6.2030	8.8357
812	22	06411055010	6	6	6	6	700700	700710	901380	771558	.0527	814657	7.7927	VERY HIGH
930	1	30012455830	10	10	5	5	932000	979000	42229000	2962045	.3451	1926802	2.0000	17.8618
932	1	30012455830	11	10	10	10	2590000	16089000	291754000	*47220741	.6004	*4491219	.6043	.5740
933	1	30012455830	10	6	5	5	2310000	2408700	104617000	7749837	.3920	10218912	1.2177	25.3501
934	1	30012455830	[illegible]	2	2	2	137207000	205282000	205282000	**8440842	.7775	*4923897	.4959	2.4311
935	1	30012455830	6	5	6	3	2410000	4632000	34900000	9359572	.4782	5721709	1.7344	1.7295
937	1	30012455830	6	6	2	2	1194000	1575000	10121000	1942836	.0769	1433376	5.6034	4.7029
938	1	30012855830	7	6	6	6	1765000	1964000	64256000	2750928	.2493	3204280	1.0012	14.3207
939	1	30012455830	2	2	2	2	90444000	96170300	96170300	*93263066	.0189	95103910	16.0750	22.5833
940	1	30012855830	5	5	3	3	1866000	3871000	21925000	4557381	.2399	3974060	2.3749	1.5567
941	1	30012455830	5	5	5	5	540000	1433000	94420000	*11690504	1.0412	32003695	.5208	1.1432
942	1	30012855830	5	5	3	3	3060000	3365000	193961000	8383113	.3971	6320738	1.2606	583.3773
943	1	30012655830	3	3	3	3	2470000	5180000	6240000	4309064	.2129	5176913	2.5555	1.6425
944	1	30012655830	6	5	3	3	2909000	4591000	202210300	*10137913	.4089	7639539	1.2305	2.4452
945	1	30012555830	6	6	6	6	1325000	1773000	3370000	2109439	.1764	2512691	2.5405	3.9599
946	1	30012455830	2	2	2	2	61080000	108982000	108982000	*81550675	.1775	94084924	2.3717	2.3981
947	1	30012855830	5	5	3	3	2687000	9361300	258006000	*11588887	.3560	8474314	1.7577	.0780
948	1	30012455830	3	3	3	3	1113000	1202000	2015000	1391740	.1402	1599327	2.7819	15.0122
949	1	30012855830	4	3	2	2	655000	4291000	219192000	3046328	.5168	2679542	.7359	.6529
952	11	10034855410	2	2	2	2	358000	16646900	16646900	2441196	1.1791	6309608	.3571	.3611
953	11	10044855410	2	2	2	2	701000	1207600	1207600	920069	.1670	1052543	2.9209	2.5489
954	11	10034855410	2	2	2	2	403700	3686100	3686100	1219869	.6792	2100000	.6199	.5264

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS • UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	KEY DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE USED FOR MLE LNM	SIZE USED FOR MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
955	11 10048999410	2	2	2	2	489700	4328600	4328600	1449966	.6717	2490642	.6268	.6338
956	22 06411055010	4	4	4	4	1182124	1532393	2234550	1671760	.1209	1877993	3.9965	4.6275
957	22 06411055010	4	4	4	4	2012660	2436020	2718000	2422374	.0571	2550126	9.8317	4.0276
958	22 06411055010	4	4	4	4	965370	1342680	2285000	1329198	.1717	1592621	2.2695	11.9516
959	22 06411055010	4	4	4	4	1119280	1444320	3094980	1797178	.1925	2182874	2.2195	4.5135
960	22 06411055010	5	5	5	5	1422410	1630680	2263680	1861134	.0845	2020612	6.1315	8.1651
961	22 06411055010	4	4	4	4	654500	789600	1482630	982980	.1634	1155681	2.8044	6.2472
962	22 06411055010	3	3	3	3	1364040	1913283	2786490	1937408	.1552	2241149	2.8069	3.5949
964	22 06411055010	4	4	4	4	1615230	2014513	3849310	2441926	.1659	2804065	2.6293	5.2093
965	22 06411055010	5	5	5	5	1014770	1136020	2271670	1452880	.1583	1717318	2.7229	9.8916
966	22 06411055010	4	4	4	4	1677290	1931830	2822060	2077276	.0992	2303857	4.0028	13.0563
967	22 06411055010	4	4	4	4	1701580	1922393	3214280	2272995	.1239	2576965	3.6599	9.6313
968	22 06411055010	4	4	4	4	1471360	1674460	2696790	2021143	.1295	2294756	3.6959	8.0954
969	22 06411055010	4	4	4	4	1288480	2215280	2684050	2043621	.1385	2308976	4.2253	2.1236
970	22 06411055010	4	4	4	4	552240	925150	1722320	960393	.2075	1182314	2.0797	2.0655
971	22 06411055010	4	4	4	4	792160	1238870	2715180	1491810	.2301	1870101	1.9098	2.5732
972	22 06411055010	4	4	4	4	1223630	1982970	3021420	1964336	.1607	2297114	2.8308	2.3828
973	22 03211055010	3	3	3	3	1019780	1022620	1313100	1110468	.0431	1182347	6.1444	437.3681
974	22 03211055010	4	4	4	4	1309440	1321733	1403060	1351649	.0142	1371623	31.2291	123.1796
975	22 03211055010	4	4	4	4	1130350	1341870	2028090	1527189	.1147	1709233	4.0623	6.7083
976	22 06411055010	4	4	2	2	642240	890155	2757270	861562	.0881	791991	4.8887	4.1031
977	22 06411055010	4	4	4	4	1683430	1719883	2270570	1896867	.0967	2069892	5.5067	7.6755
978	22 06411055010	4	4	4	4	919450	1603860	2024170	1522066	.1518	1740165	3.9142	2.0607
979	22 06411055010	4	4	4	4	958990	1549380	2606560	1745322	.1967	2098530	2.6689	2.4517
980	22 06411055010	4	4	4	4	1124040	1265493	1488100	1328944	.0581	1403878	8.8163	9.7083
981	22 06411055010	4	4	4	4	839160	951900	1251210	1000971	.0724	1079019	5.5193	9.1285
982	22 06411055010	4	4	4	4	987700	1293123	1498350	1212101	.0696	1297005	6.5705	5.9375
983	22 06411055010	4	4	4	4	946550	957260	1236500	1051017	.0546	1112053	7.6732	102.2757
984	22 06411055010	4	4	4	4	1041980	1049020	1173590	1102090	.0267	1133031	16.5458	170.8923
985	22 06411055010	4	4	4	4	990080	1068270	1168500	1051300	.0367	1090753	11.6098	11.7003
986	22 06411055010	3	3	2	2	905250	1600710	3260950	1441423	.1581	1385816	2.4094	2.1341
987	22 06411055010	4	4	4	4	200810	942703	1484130	737477	.3899	1037267	1.9929	.8023
1000	5 03111021010	3	3	3	3	1780	2310	3250	2373	.1311	2688	3.2516	4.6671
1001	5 03111021010	4	4	4	4	6600	11100	19600	11206	.1650	13014	3.3619	2 2135
1002	5 03111021010	5	5	5	5	21300	23600	28300	24555	.0449	25712	9.9943	10.8008
1003	5 03111021010	4	4	4	4	33700	37100	47900	39381	.0633	42018	6.5108	11.9719
1004	5 03111021010	3	3	3	3	187800	213800	231600	210288	.0460	219.10	10.6060	9.3812
1005	5 03111021010	3	3	3	3	17100	21300	24600	20770	.0795	22326	5.9683	5.5384
1006	5 03111021010	3	3	3	3	48500	50600	70100	55616	.0875	60665	6.6685	20.6968
1007	5 03111021010	5	5	5	5	217600	217700	621800	279483	.1196	317867	3.3114	2628.3597

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS • UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	FIG DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR LNA	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
1008	5 03111021010	3	3	3	3	11900	16100	17800	15052	.0910	16297	5.7832	4.0241
1009	5 03111021010	3	3	3	3	8341	8705	9234	8644	.0302	8888	15.3679	15.3306
1010	5 03111021010	3	3	3	3	60100	61600	67400	62956	.0262	64602	15.0820	49.3626
1012	6 03911028010	2	2	2	2	32000	37000	37000	34409	.0446	35667	9.4437	9.5487
1013	6 03911028010	2	2	2	2	704000	762000	762000	732426	.0243	751121	13.6863	17.5107
1014	6 03911028010	2	2	2	2	4000	5000	5000	4472	.0685	4726	6.1443	6.2126
1015	6 03911028010	2	2	2	2	853000	998000	998000	922656	.0482	959186	8.7332	8.8303
1016	6 03911028010	3	3	3	3	10000	14000	19000	13856	.1394	15769	3.2183	3.6151
1017	6 03911028010	3	3	3	3	78000	310000	332000	200231	.3549	270640	1.6397	.8815
1018	6 03911021010	3	3	3	3	43000	43000	56000	46958	.0662	50197	5.8481	VERY HIGH
1019	6 03911021010	3	3	3	3	108000	118000	131000	118629	.0470	123422	10.2939	13.7363
1020	6 03911021010	3	3	3	3	37000	40000	48000	44113	.1043	48906	3.7602	15.6025
1021	6 03911021010	3	3	3	3	98000	118300	130000	114556	.0624	121131	7.8833	6.5497
1022	6 03911021010	3	3	3	3	166000	181000	206000	183605	.0472	192079	8.8978	14.0609
1023	6 03911021010	3	3	3	3	285000	364000	474000	366360	.1105	406308	3.9583	4.9717
1024	6 03911021010	3	3	3	3	420000	438000	446000	434530	.0134	440602	30.3602	28.9865
1025	6 03911021010	7	7	7	7	37000	40000	58000	46638	.0779	50677	5.9372	13.8409
1026	6 03911021010	7	7	7	7	89000	98000	131000	112166	.0625	119455	8.2218	11.2015
1027	6 03911021010	3	3	3	3	165000	181000	206000	183605	.0472	192079	8.8978	14.0609
1028	6 03911021010	7	7	7	7	199000	288000	474000	361248	.1362	409705	4.6072	3.0042
1029	7 03111021010	3	3	3	3	36700	42200	49700	42538	.0659	45267	6.5613	8.7107
1030	7 03111021010	3	3	3	3	42400	80300	90200	67468	.1765	78484	3.1697	1.9347
1031	7 03111021010	5	5	5	5	137200	142700	222800	161356	.0830	177166	4.3031	28.3863
1032	7 03111021010	3	3	3	2	306100	449400	798400	478894	.2096	407794	3.5705	3.1677
1033	7 03111021010	3	3	3	3	726600	963700	976600	881018	.0725	936927	8.0261	4.3373
1034	7 03111021010	3	3	3	3	95500	114100	202500	130641	.1680	154244	2.3467	7.2687
1035	7 03111021010	3	3	3	3	91900	112100	129800	110170	.0753	118076	6.1637	4.1221
1036	7 03111021010	3	3	3	3	324900	378900	415300	371147	.0539	389637	8.9233	7.9119
1037	7 03111021010	3	3	3	3	473000	576000	796600	600954	.1143	670712	3.6367	6.1742
1039	7 03111021010	3	3	3	3	18700	19700	34500	23337	.1475	27020	2.6340	23.3495
1040	7 03111021010	3	3	3	3	39500	58900	79800	57048	.1532	65651	3.0138	3.0645
1041	7 03111021010	3	3	3	3	68700	208200	468700	180289	.4178	275886	1.1129	1.0971
1042	7 03111021010	3	3	3	2	409300	513600	1148000	622591	.2354	684971	6.0406	5.3587
1043	7 03111021010	3	2	2	2	954000	1139900	1139900	1042816	.0387	1090067	7.7476	6.8324
1044	7 03111021010	2	2	2	2	28200	46000	46000	36017	.1505	40690	2.8020	2.8331
1045	7 03111021010	3	3	3	3	77100	120100	162900	114685	.1634	133086	2.8732	2.7444
1046	7 03111021010	3	3	3	3	199200	242900	269200	230683	.0799	247558	6.3780	6.8141
1047	7 03111021010	3	3	3	3	384600	488300	564900	473394	.0843	510869	5.6909	5.8954
1048	7 03111021010	3	3	3	3	21400	28400	33900	27414	.1000	30033	6.7323	6.2982
1049	7 03111021010	2	2	2	2	75100	91400	91400	83400	.0563	87266	7.6841	7.5672

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	FFE	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR LNM	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
1050	7	0311102101[illegible]	6	3	3	3	274430	225400	474600	296666	.1491	360399	2.1856	258.7784
1052	7	0311102101[illegible]	11	11	11	11	33500	59[illegible]	202500	92699	.1976	115080	2.2146	2.6243
1053	7	0311102101[illegible]	9	8	9	8	18700	19700	46000	27630	.1358	32039	3.1559	20.5058
1054	7	0311102101[illegible]	13	12	12	12	58700	198200	479600	266359	.2184	330891	2.4981	1.0325
1055	7	031110210[illegible]	5	5	6	6	439300	473000	1148000	611677	.1657	795822	2.3152	7.5628
1056	7	0311102101[illegible]	5	4	4	4	830600	942700	1139900	948431	.0503	1013768	6.9661	17.9184
1057	5	0421102801[illegible]	4	4	4	4	28000	28[illegible]	70000	43952	.2262	54939	2.1096	VERY HIGH
1058	4	042110280[illegible]	[illegible]	4	2	2	57000	93000	312000	95189	.1539	82170	2.8007	2.3506
1059	4	0421102801[illegible]	[illegible]	2	2	2	206000	312000	312000	253519	.0901	281056	3.3166	2.7723
1060	4	0421102801[illegible]	[illegible]	2	2	2	57000	93000	93000	212515	.5186	395781	.5655	2.3506
1061	[illegible]	042110240[illegible]	4	4	4	4	4000	4300	5000	4229	.0485	4459	7.4260	VERY HIGH
1062	5	0421102401[illegible]	4	4	4	4	13000	13000	17000	12193	.1102	13671	3.5643	VERY HIGH
1063	4	[illegible]	[illegible]	[illegible]	4	3	56000	79000	174000	88861	.2123	77641	5.4249	3.0245
1064	4	0821102401[illegible]	4	4	4	4	411000	433000	1020000	639849	.1838	768084	2.4760	5.3256
1065	5	0421102401[illegible]	4	2	2	2	433000	811000	811000	819405	.1776	961195	1.7612	2.3118
1066	5	0421102601[illegible]	4	2	2	2	411000	10[illegible]0000	1020000	828975	.2088	957[illegible]59	1.8260	1.2660
1067	4	04211028[illegible]	4	4	[illegible]	4	6300	9000	11000	8779	.1158	9733	4.9811	2.8383
1068	4	0421102801[illegible]	[illegible]	4	4	4	16000	15100	21000	16547	.0773	17937	5.1448	16.6783
1069	[illegible]	[illegible]	4	4	4	4	1[illegible]6000	117000	141000	119535	.0566	126414	7.4580	9.7599
1070	5	[illegible]	[illegible]	4	4	4	266300	257000	477000	310472	.1295	356752	2.8839	12.7765
1072	4	[illegible]	4	4	4	4	746000	833000	1077000	882461	.0599	941082	6.2206	19.8139
1073	4	05011[illegible]	[illegible]	4	4	4	6300	6300	8500	6830	.1556	7781	4.4391	1.6501
1074	4	05011[illegible]	[illegible]	4	4	4	23000	44000	108000	52964	.2896	70019	1.5499	1.7733
1079	4	05011[illegible]	[illegible]	4	4	2	385000	452000	1131000	612696	.2111	434043	8.5457	7.1724
1080	4	05011[illegible]	4	4	2	2	3000	5000	14500	5123	.1606	4306	2.6840	2.2527
1031	[illegible]	05011[illegible]	4	4	2	2	13000	15000	85000	15102	.0450	14467	9.5811	8.0414
1042	4	[illegible]	4	[illegible]	4	4	124000	455000	6[illegible]	340444	.2985	444721	1.6996	1.0353
1043	[illegible]	[illegible]	[illegible]	[illegible]	4	4	4500	5500	9000	5916	.1282	6782	2.9519	5.7344
1044	[illegible]	[illegible]	4	4	4	4	11000	14000	32300	18140	.2063	22331	2.1066	4.7715
1045	4	[illegible]	[illegible]	[illegible]	[illegible]	4	72000	[illegible]	166000	124093	.1647	143486	4.6224	2.9303
1046	[illegible]	[illegible]	4	4	[illegible]	3	1500	2700	15500	1911	.0662	1932	8.1007	4.0000
1047	[illegible]	[illegible]	[illegible]	4	[illegible]	4	14000	[illegible]	135000	50412	.6501	76933	1.1390	1.0238
1048	[illegible]	[illegible]	[illegible]	4	4	4	164000	255000	367000	260789	.1469	298894	3.4856	2.3983
1049	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	4600	5000	5500	4583	.1035	5033	5.2240	3.4106
1050	[illegible]	[illegible]	[illegible]	4	[illegible]	3	[illegible]	17000	46000	21436	.2235	17227	12.4036	9.1938
10[illegible]1	[illegible]	[illegible]	[illegible]	4	[illegible]	4	[illegible]	[illegible]	[illegible]	241112	.3167	311036	1.6573	1.6557
10[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2[illegible]	951127	.2763	623497	5.1467	4.3192
10[illegible]	[illegible]	[illegible]	7	[illegible]	[illegible]	5	[illegible]	[illegible]	12[illegible]	562970	.1990	597777	2.7183	26.7590
10[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11[illegible]	1[illegible]	6910	.4712	10[illegible]	1.1875	.7135
1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]14	.0218	23[illegible]7	18.6267	13.9797

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR MLE LNM	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE -BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
1096	[illegible]	3	3	3	3	36000	38000	46000	39775	.0559	42027	7.0747	22.4978
1097	[illegible]	3	3	3	3	59000	76000	79000	74547	.0303	76564	16.9326	12.5985
1098	[illegible]	2	2	2	2	42000	43000	43000	42497	.0072	42817	43.9862	58.9148
1099	[illegible]	2	2	2	2	496000	574000	574000	532500	.0461	552638	9.1767	9.2362
1100	[illegible]	8	8	8	8	57800	62300	136000	92991	.1413	107563	3.6036	14.2485
1101	[illegible]	7	7	7	7	43900	52100	80000	63154	.0853	69099	5.5345	17.0231
1102	[illegible]	10	10	10	10	101000	104000	175000	130850	.0827	143190	5.5105	35.9955
1103	[illegible]	10	10	10	10	145000	147300	382000	250441	.1155	281825	4.2174	4.1619
1104	[illegible]	10	10	10	10	400000	400000	1236000	621188	.1438	732188	2.6684	VERY HIGH
1105	[illegible]	4	4	4	4	7000	9000	12000	9325	.0978	10250	4.7694	4.5788
1106	[illegible]	4	4	4	4	37000	37000	63000	43626	.1095	49100	3.3726	VERY HIGH
1107	[illegible]	4	4	4	4	452000	506000	687000	533092	.0775	578969	4.8821	10.1366
1108	[illegible]	4	4	4	4	4300	6000	7000	5091	.1241	5765	3.6192	VERY HIGH
1109	[illegible]	5	5	3	3	3000	5000	15000	5663	.1706	5138	3.3404	2.1841
1110	[illegible]	3	3	3	3	42000	48000	49000	46227	.0364	47687	15.5553	9.1394
1111	[illegible]	4	4	4	4	196000	199000	204000	200227	.0076	201813	58.0719	75.7548
1112	[illegible]	4	4	4	4	283000	377000	618000	421551	.1402	484585	3.1699	4.3290
1113	[illegible]	5	5	5	5	4000	4700	8000	5573	.1387	6409	3.4396	VERY HIGH
1114	[illegible]	4	4	4	2	4000	6000	15000	8271	.2735	5415	3.3815	2.8383
1115	[illegible]	3	3	3	3	8000	10000	11000	9583	.0710	10204	7.1512	5.4512
1116	[illegible]	3	3	3	3	27000	43000	51000	38976	.1430	44189	3.6326	2.6139
1117	[illegible]	4	4	4	4	51000	58000	91000	65409	.1084	73188	3.7110	8.9669
1118	[illegible]	4	4	4	4	121000	135000	253000	154536	.1449	180850	2.5184	10.5104
1119	[illegible]	5	5	5	5	13000	15000	30000	18971	.1924	22841	2.6661	2.7517
1120	[illegible]	5	5	5	5	10000	12300	27000	16178	.1710	19275	2.5996	6.1195
1121	[illegible]	4	4	4	4	185000	176000	273000	211201	.0758	229267	4.8351	19.9233
1122	[illegible]	4	4	4	4	9000	10000	13000	10400	.0681	11183	5.5510	10.9218
1123	[illegible]	4	4	4	4	23000	28000	30000	27359	.0517	28620	11.8696	5.8699
1124	[illegible]	4	4	3	3	47000	64000	534000	61998	.0765	62597	7.0572	3.7272
1125	[illegible]	5	5	4	5	139000	143000	411000	269771	.2116	326109	2.6946	4.0570
1126	[illegible]	4	4	4	4	6000	7000	9000	7172	.0729	7737	5.4370	7.4650
1127	[illegible]	3	3	3	3	16000	16000	18000	16641	.0295	17137	13.1156	VERY HIGH
1128	[illegible]	4	4	4	4	37000	50000	81000	59985	.1498	68686	3.7242	2.3806
1129	[illegible]	3	3	3	3	107000	109000	152000	120656	.0869	131552	4.4595	130.7616
1130	[illegible]	4	4	4	4	7000	7300	8000	7483	.0335	7735	14.2607	VERY HIGH
1131	[illegible]	4	4	4	4	12000	13000	15000	13654	.0417	14016	10.9320	16.3766
1132	[illegible]	4	4	4	4	23000	39300	58000	38217	.1658	44745	2.8991	2.1791
1133	[illegible]	2	2	2	2	151000	164000	164000	157366	.0254	161558	12.5449	16.7859
1134	[illegible]	4	4	4	4	373000	388000	814000	511047	.1600	602384	2.5960	29.1864
1135	[illegible]	4	4	4	4	5000	7300	8000	6654	.0871	7195	6.3777	3.4203

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE USED FOR MLE LNM	SIZE USED FOR MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
1136	72	00010406010	4	4	4	4	11000	13000	24000	16576	.1671	19528	2.0669	6.0004
1137	72	00010405013	4	4	2	2	53000	59000	248000	69299	.0286	67432	15.0713	12.6493
1138	72	00010406013	3	3	2	2	60000	93000	229000	63534	.1125	81227	3.3015	3.0309
1139	72	00010406010	6	6	6	6	183000	196000	727500	519987	.3496	686390	1.3139	30.0797
1140	4	08211028010	3	2	2	2	831	936	936	881	.0359	907	11.7339	11.8642
1181	4	08211028010	4	4	4	4	1173	1736	2000	1639	.1005	1791	5.7920	2.9356
1182	4	08211028010	2	2	2	2	29	101	101	76	.3032	76	1.0900	1.1110
1183	4	08211028010	3	3	3	3	257	202	383	310	.0072	337	6.0253	7.5300
1184	4	15011028010	4	4	4	4	14	55	194	67	.5025	106	1.0603	.8301
1185	4	35011028010	4	4	4	3	106	283	637	273	.3190	255	2.3360	1.1718
1186	4	35011028010	2	2	2	2	116	497	497	240	.4468	344	.9423	.9528
1187	4	35011028010	4	4	4	2	63	69	189	96	.2190	67	15.0713	12.6493
1188	4	05011028010	4	4	4	4	121	270	288	209	.1640	241	3.5096	1.7916
1189	4	03411028010	3	3	3	3	51	413	769	262	.6296	450	.0752	.5542
1190	4	03411028010	3	3	3	3	34	60	96	60	.2283	74	2.1291	1.8339
1191	4	03411028010	3	3	3	2	262	350	935	425	.2620	325	6.7365	6.2004
1192	72	00010406010	2	2	2	2	500	535	635	563	.0734	598	5.7363	5.0000
1193	72	00010406010	4	4	4	4	1278	1328	1546	1409	.0414	1468	11.4905	35.5873
1194	72	00010406010	5	6	5	6	1732	1752	2529	1923	.0625	2068	5.4067	95.2802
1195	72	00010406010	4	5	4	5	2735	3520	5900	3783	.0995	4180	4.5706	4.4217
1196	72	00010406010	3	3	3	3	7	42	52	25	.4783	37	1.1962	.6789
1197	72	00010806010	4	4	4	4	576	625	759	660	.0533	696	8.4077	13.5185
1198	72	00010406010	4	4	4	4	1170	1230	1591	1340	.0616	1434	7.1193	23.0098
1199	72	00010806010	4	4	2	2	21	47	4119	49	.2532	38	1.7019	1.6236
1200	72	00010806010	10	10	5	5	30	35	4135	423	.7892	158	.8609	6.8349
1201	72	00010406010	4	4	4	4	4339	4719	6017	5106	.0643	5442	7.0944	13.6493
1202	72	00010406010	3	3	3	3	5	85	471	58	.9970	144	.4811	.4293
1203	72	00010406010	4	4	4	4	63	2298	4100	1131	.8426	2206	.7902	.3199
1204	72	00010406010	4	4	4	4	2965	3064	4161	3323	.0674	3573	5.5193	29.0497
1240	5	03111021010	3	2	2	2	838600	1305000	1335000	2721232	.6162	5295130	.4058	2.7506
1241	5	03111021010	5	5	3	3	1166200	1597100	7219000	2142554	.1052	1892942	2.7963	3.5276
1242	5	03111021010	2	2	2	2	6551000	[illegible]	8640000	7529080	.0845	8099495	6.9810	5.0363
1243	5	03111021010	6	6	5	4	556600	1372800	17040000	1793960	.3123	1396197	3.1067	1.2361
1244	5	03111021010	3	3	2	2	1970600	4816100	16245200	4086209	.2479	3842010	1.5341	1.3610
1245	5	03111021010	3	3	3	2	3821600	5608500	10403200	6063807	.2195	5089565	3.5736	3.1705
1246	5	03911026010	3	2	2	2	2208000	4089000	4089000	7419622	.5889	13858329	.4309	1.9740
1247	6	03411028010	3	2	2	2	2286000	4640000	4640000	3295420	.2177	3879171	1.9344	1.9559
1249	6	03411021010	3	3	3	3	1046000	1162000	1838000	1307257	.1302	1406619	3.0199	11.5661
1250	6	03911021010	3	3	3	3	759000	1474000	1674000	1232627	.1845	1444279	3.0219	1.8327
1251	6	03911021010	7	7	7	7	152000	759000	1928000	948493	.3628	1296940	1.9211	.6987

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	KEY DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE USED FOR MLE LGN	WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE -BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
1252	6 03211021010	4	3	3	3	2051000	6000000	13138000	5447728	.4049	7889491	1.1477	1.1332
1253	7 03111021010	4	3	3	3	1547500	2135200	3012700	2151507	.1447	2463635	3.0280	3.7731
1254	7 03111021010	4	2	2	2	2219560	3222300	3222300	6964702	.6153	13578384	.6049	3.2627
1255	7 03111021010	4	2	2	2	5157100	7151600	7151600	11071019	.3276	15822530	.7575	8.2129
1256	7 03111021010	4	2	2	2	4055100	6692700	6692700	9814519	.4154	15183943	.6164	2.4277
1257	7 03111021010	4	4	4	4	864100	957900	1206600	1032690	.0612	1097148	7.4683	14.3930
1258	7 03111021010	4	4	4	4	1395000	1625202	1655300	1470106	.0434	1534749	10.1788	13.1749
1259	7 03111021010	4	2	2	2	1187100	1540700	1540700	5324597	.7550	12976829	.3386	4.4136
1261	7 03111021010	4	4	4	4	4055100	5167100	7151600	7363968	.1323	7708025	4.5552	2.5480
1262	4 09211028010	4	3	3	3	958000	1218000	1493000	1316317	.0993	1434945	4.1886	4.7924
1263	3 08211024010	4	3	3	3	1161000	1301000	1368000	1314221	.0362	1353000	12.4166	10.1073
1264	4 08211028010	4	2	2	2	10876000	26373300	26373300	25460829	.2777	31890476	1.1872	1.2991
1265	6 08211028010	4	4	4	4	1298000	1521000	1701000	1539576	.0539	1616990	10.3367	7.2581
1266	4 08211028010	4	2	2	2	4926000	12200000	12200000	23761584	.5092	42025011	.4767	1.2688
1267	4 05011028010	4	3	2	2	1403000	4754000	11202000	5037858	.3836	6106692	1.0114	.9429
1268	5 05011028010	4	3	2	2	518000	1232000	6817000	1281476	.2604	1460295	1.4897	1.3089
1269	4 05011028010	4	2	2	2	6804000	9585000	9585000	27517998	.5942	48389020	.4764	3.3579
1270	4 05011024010	4	4	4	4	606000	1433000	3226300	1522701	.3040	2033399	1.5939	1.3371
1271	8 05011028010	4	2	2	2	8101000	29110000	29110000	30321634	.3974	37713712	.9494	.8996
1272	4 03411028010	4	4	2	2	528000	591000	2365000	594173	.0354	574405	12.1635	10.2088
1273	4 03411024010	4	4	2	2	1699000	2144000	49525000	2189636	.0779	2032366	5.5325	4.6434
1276	4 03411024010	4	2	2	2	4474000	8944000	8944000	39264261	.8777	84939787	.3338	1.6612
1277	7 03111021010	6	6	6	5	904100	957900	1540700	1201521	.0970	1193185	7.8100	13.3243
1278	47 06411821010	3	3	3	3	1720000	2558000	4203000	2644416	.1944	3177391	2.2095	3.0647
1279	20 03211021010	10	10	10	9	259000	1197000	16533000	1869059	.4418	1913474	2.2601	.6883
1300	20 03211021010	7	7	7	7	643000	744000	972000	799035	.0605	852322	7.2746	7.3960
1301	20 03211021010	7	7	7	7	688000	736900	1467000	876935	.1704	1053925	2.9630	2.9219
1302	20 03211021010	7	7	7	7	453000	489000	814000	640975	.1015	716924	5.4990	14.1108
1303	20 03211021010	7	7	7	7	444000	444000	583000	507581	.0509	535708	9.2352	VERY HIGH
1304	20 03211021010	7	7	7	7	406000	643000	978000	685100	.1103	769054	4.2903	2.3468
1305	20 03211021010	7	7	7	7	519000	633000	941000	768739	.0942	839063	6.5690	5.2304
1306	20 03211021010	7	7	7	7	532000	614000	941330	725457	.0984	795812	5.2795	7.5273
1307	20 03211021010	7	7	7	7	560000	572000	773000	706758	.0775	767040	5.7538	90.8935
1308	20 03211021010	6	6	4	6	487000	627000	950000	696778	.1262	786558	3.8926	4.5540
1540	20 03211021010	7	7	7	7	456000	955000	1283000	995698	.0915	1084423	5.8711	2.8733
1541	20 03211021010	7	7	7	7	1084000	1261003	1825000	1316901	.0684	1427641	4.9808	7.1344
1542	20 03211021010	3	3	3	3	7736000	10269003	12225000	9902094	.1004	10842776	4.7654	4.2986
1543	20 03211021010	4	4	4	4	4556000	4556000	5625000	4859466	.0435	5092966	8.4790	VERY HIGH
1544	20 03211021010	5	5	5	5	163000	1214000	9537000	2213469	.7587	4403567	.7537	.9557
1545	20 03211021010	7	7	7	7	1923000	2355000	4229000	2905736	.1350	3357150	3.3779	5.3246

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR LNM	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(INF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE -BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
1546	20	03211021010	7	7	7	7	734000	744000	1300000	931490	.0962	1034124	4.4566	79.7409
1547	0	03211021010	7	7	7	7	1132000	1142000	2120000	1594553	.1239	1811247	4.1194	122.6877
1548	20	03211021010	7	7	7	7	1549000	1819000	3250000	2224785	.1101	2502110	3.9914	6.7157
1549	20	03211021010	7	7	4	4	1141000	1630000	10432000	1794917	.1004	1694666	6.0391	3.0293
2300	31	00056283011	4	3	3	3	36300	49700	68300	49762	.1373	56566	3.2162	3.0716
2301	31	00057083011	3	3	3	3	873600	895400	1309500	1008041	.0986	1111840	3.9399	49.3500
2302	31	00059083011	2	2	2	2	16960	30000	30000	22557	.1752	25974	2.4039	2.4306
2303	31	00053183011	2	2	2	2	30000	35000	35000	32404	.0473	33663	8.8963	8.9931
2304	41	00053083011	2	2	2	2	250000	400000	400000	316228	.1443	395209	2.9171	2.9495
2305	41	00056083011	2	2	2	2	11932	13356	13356	12571	.0372	12953	11.3163	11.4420
2306	31	00056183011	3	3	3	3	92634	108674	161506	97393	.2449	121558	1.9756	1.6778
2307	31	00055263011	3	3	3	3	350000	369900	550900	430216	.1488	500029	2.6117	21.9965
2308	31	00055183011	3	3	3	3	11000	12000	17000	13092	.1001	14450	3.9309	13.9797
2309	41	00055083011	3	3	3	3	879600	1115200	1674700	1170466	.1350	1333412	3.0676	5.1255
2310	32	00055181011	2	2	2	2	59400	97000	97000	75907	.1506	85699	2.7957	2.8268
2311	32	00055081011	2	2	2	2	9000	11700	11700	10267	.0006	10950	5.2258	5.2939
2312	32	00055081011	3	3	3	3	8500	20500	31200	17652	.2854	22764	1.7439	1.4303
2313	32	00055283011	2	2	2	2	32000	39000	39000	35327	.0408	37098	6.9307	7.0077
2314	32	00051181011	2	2	2	2	351000	398000	398000	379049	.0300	391008	10.6186	14.2076
2315	32	00051181011	2	2	2	2	672600	1438400	1438400	983599	.2334	1187041	1.8037	1.8237
2316	33	01055281010	2	2	2	2	36500	40600	40600	37426	.0500	38964	8.4213	8.5149
2317	34	05111041090	3	3	3	3	202000	229000	270000	232015	.0632	246365	6.7443	9.6950
2318	64	00011141021	3	3	2	2	15164	16413	16413	15776	.0243	16179	13.0096	17.5149
2319	64	00011141021	2	2	2	2	3405	4169	4169	3768	.0622	3961	6.7730	6.0402
2320	64	00011141021	2	2	2	2	13000	16000	16000	14422	.0638	15182	6.6031	6.6765
2321	64	00011141021	[illegible]	2	2	2	13851	20329	20329	16786	.1176	18454	3.5001	3.6199
2322	64	00011141021	[illegible]	2	2	2	5496	8129	8129	7266	.0689	7680	6.1173	6.1853
2323	64	00011141021	[illegible]	2	2	2	7118	8473	8473	7766	.0535	8109	7.8680	7.9554
2324	64	00011141021	[illegible]	2	2	2	14011	15069	15069	14530	.0274	14871	14.2312	19.0433
2325	1	[illegible]	[illegible]	2	2	2	879935	976005	976005	926726	.0318	957805	9.9993	13.3707
2326	1	[illegible]	[illegible]	3	3	3	783601	911933	938001	871964	.0405	902562	14.1592	8.0067
2327	1	[illegible]	[illegible]	3	3	3	337348	421764	473989	390180	.1048	427802	5.0067	3.5121
2328	1	[illegible]	[illegible]	2	2	2	658764	757582	757582	695441	.0526	725620	8.0369	8.1261
2329	1	[illegible]	[illegible]	2	2	2	214881	394309	394309	293780	.1808	339817	2.3293	2.3552
2330	64	[illegible]	[illegible]	4	4	4	215000	255000	745000	408517	.2143	508422	2.2283	6.4113
2331	64	[illegible]	[illegible]	[illegible]	[illegible]	4	213000	225300	772300	432961	.2379	566088	2.2777	15.8557
2332	[illegible]	[illegible]	[illegible]	4	4	4	155300	205307	240300	198844	.0790	214039	6.3860	4.1158
2333	64	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	138000	155300	160003	150699	.0338	155186	15.9432	10.4707
2334	[illegible]	[illegible]	[illegible]	[illegible]	2	2	255000	515300	515300	362398	.2159	431195	1.9506	1.9722
2335	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	425000	450200	450300	437321	.0176	445354	18.1226	24.2535

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR MLE LNM	SIZE FOR MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TDS-ALFA)
2336	68	00056081021	2	2	2	2	470000	480000	480000	474974	.0065	478172	49.1539	65.0465
2337	68	00056081021	6	5	6	4	138000	143300	545000	193337	.2280	152719	14.3932	76.0268
2338	68	00056081021	6	6	6	6	5000	5500	18000	9801	.2294	12307	2.1097	11.4776
2339	68	00055381021	5	5	5	5	11000	11000	21000	14492	.1220	16450	3.5595	VERY HIGH
2340	69	00056041021	3	3	3	3	11000	19000	27000	17803	.1965	21277	2.4155	2.2235
2341	68	00056081021	6	5	6	6	26000	30400	51000	37446	.1154	42208	4.0170	6.9968
2342	68	00056081021	6	6	6	6	5000	5500	51000	17723	.4353	27339	1.1925	11.4776
2343	68	00056081021	6	5	5	6	50000	51000	73000	59491	.0714	64157	6.2777	55.2416
2344	68	00056081021	4	4	4	4	66000	86500	95800	83993	.0721	89464	8.3951	4.2942
2345	68	00056081021	4	4	4	4	44000	46000	90500	56441	.1434	65000	2.6195	25.0071
2346	68	00056081021	2	2	2	2	40000	82000	82000	57271	.2205	68399	1.9100	1.9312
2347	69	00056081021	2	2	2	2	51500	54000	54000	52735	.0146	53537	21.0500	29.2455
2348	69	00056081020	4	4	5	4	1534	2146	2409	2077	.0903	2240	6.0940	5.4276
2349	69	00056C81020	2	2	2	2	4656	5826	5826	5208	.0489	5505	6.1161	6.1940
2350	69	00056081020	2	2	2	2	24288	29558	29558	26794	.0403	28127	6.9820	7.0595
2351	69	00056081070	2	2	2	2	147837	152007	152007	149908	.0086	151242	37.2170	49.0376
2352	69	00056381070	3	3	3	3	38549	40348	52170	43293	.0709	46440	9.5108	36.6505
2353	69	00056781050	3	3	3	3	44765	45963	51299	47259	.0314	48746	12.9440	46.0579
2354	69	00056081070	2	2	2	2	77291	82332	82332	79772	.0194	81393	16.3956	21.9412
2355	69	00056081070	2	2	2	2	37575	58338	58338	46819	.1351	52201	3.1167	3.1513
2621	31	00056383011	3	3	3	3	1192	1200	1700	1345	.0882	1468	4.3929	101.0504
2622	31	00055083011	3	3	3	3	1000	1000	2000	1260	.1738	1498	2.2207	VERY HIGH
2623	32	00056089011	3	3	3	3	3860	6610	7190	5682	.1446	6441	3.0945	2.2613
2624	64	00011081021	2	2	2	2	1861	1873	1873	1867	.0020	1871	166.4400	215.6836
2625	69	00056081020	2	2	2	2	619	900	900	746	.1150	819	3.6631	3.7058
2461	31	00055089011	2	2	2	2	1403400	1894600	1894600	1630888	.0922	1790243	4.5605	4.6195
2500	31	00055389011	3	3	3	3	23782	26025	29865	25098	.0743	26765	6.6074	5.4060
2502	31	00011089011	3	3	3	3	25600	35400	42530	33771	.1115	37333	4.3524	3.7529
2503	31	00050043010	3	3	3	3	23140	29640	38600	27600	.0660	29230	8.9060	4.9135
2534	31	00010089010	3	3	3	3	40000	42500	47700	43284	.0309	44940	10.5605	20.0644
2505	32	00055083010	3	3	3	3	116000	121200	164600	132271	.0028	143592	4.7001	27.7387
2621	31	00055081011	2	2	2	2	530	679	679	600	.0761	638	5.5342	5.5957
2622	32	00056089011	2	2	2	2	468	634	634	545	.0932	587	4.5163	4.5665
2623	32	00055081011	3	3	3	3	8250	9710	9790	9222	.0419	9556	13.0795	7.4652
2624	32	00056083010	2	2	2	2	1280	2000	2080	1632	.1491	1840	2.0240	2.0593
2625	32	00056083010	2	2	2	2	1225	1560	1560	1382	.0742	1468	5.6715	5.7345
2661	31	00010389010	3	3	3	2	908600	1314000	2505000	1335438	.2496	996266	12.4922	11.0833
2701	31	00055381011	3	3	3	3	15400	26000	44900	26197	.2324	32561	1.0913	2.3226
2702	32	00055381011	2	2	2	2	13000	14500	14500	13730	.0335	14105	12.5556	12.6951
2733	32	00055384011	2	2	2	2	15300	17200	17200	16222	.0360	16699	11.7128	11.0429

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR LNM	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
2704	32	00055086011	2	2	2	2	790000	1070000	1070000	919602	.0932	991042	4.5198	4.5695
2705	32	00056081011	5	5	5	5	7500	14700	28100	16988	.2239	20935	2.4665	1.6583
2706	32	00055081010	2	2	2	2	16800	21100	21100	18828	.0700	19919	6.0162	6.0031
2707	32	00055084010	2	2	2	2	22500	23500	23500	22995	.0134	23315	23.8167	31.0797
2708	32	00055081010	3	3	3	2	11200	17300	32100	16390	.2290	19499	3.1534	2.7976
2709	36	06411921011	3	3	3	3	9000	9000	9700	9220	.0108	9409	21.6367	VERY HIGH
2710	36	06411921010	3	3	3	3	9000	9300	9700	9228	.0109	9409	21.6367	VERY HIGH
2711	36	06411921011	6	6	6	5	32000	33300	131100	58104	.2270	98124	3.0066	72.3074
2712	36	06411921010	6	6	6	6	32800	34600	131100	61436	.2309	78275	1.8972	20.4759
2713	36	06411921011	4	4	2	2	40100	59600	162900	60733	.1246	59916	3.6990	2.9090
2714	36	06411971013	4	4	2	2	40100	60000	164000	61160	.1267	54186	3.6824	2.0996
2721	36	06411812011	2	2	2	2	30400	31400	31400	30896	.0099	31216	31.9913	42.0320
2722	36	06411912010	2	2	2	2	30400	33000	33000	31673	.0292	32512	12.0246	10.0926
2723	36	06411812011	4	4	4	4	21600	55200	176100	66582	.3096	96994	1.2250	1.2206
2724	36	06411812010	4	4	4	4	24800	58800	176100	70019	.3586	99133	1.2908	1.3329
2727	36	10211811011	2	2	2	2	20800	21200	21200	20999	.0059	21127	94.3191	72.7783
2728	36	10211911010	2	2	2	2	21800	22200	22200	21999	.0056	22127	96.9012	76.2641
2729	36	10211011011	4	4	4	4	20000	26700	41200	27008	.1299	31770	3.1329	4.2615
2730	36	10211011010	4	4	4	4	24100	26600	41200	29246	.1024	32696	3.6183	11.6589
2731	36	10211011011	4	4	4	4	28800	45700	74500	50684	.1875	60397	2.7085	2.4922
2732	36	10211011010	4	4	4	4	48240	62600	74500	62379	.0806	67166	6.9051	4.4161
2733	36	10211922011	2	2	2	2	32700	124500	124500	63006	.4106	88810	1.0299	1.0367
2734	36	10211822010	2	2	2	2	32700	126100	126100	64214	.4145	89661	1.0150	1.0271
2735	36	10211922011	2	2	2	2	50800	51200	51200	51000	.0026	51128	131.6082	176.7516
2736	36	10211922010	2	2	2	2	50800	52300	52300	51545	.0089	52025	35.5770	47.6390
2737	36	10211922011	2	2	2	2	21200	24800	24800	22929	.0482	23636	8.7416	8.0300
2738	36	10211822010	2	2	2	2	21200	24800	24800	22929	.0482	23836	8.7416	8.0300
2739	36	10211422011	2	2	2	2	43200	63000	63000	52169	.1159	57271	3.6339	3.6743
2740	36	10211622010	2	2	2	2	43200	63000	63000	52169	.1159	57271	3.6339	3.6743
2741	36	10211422011	6	6	6	5	13900	18200	57900	22978	.1962	21420	4.9930	4.0586
2742	36	10211522010	6	6	6	5	13900	18200	52800	23000	.1971	21420	4.9930	4.0586
2743	36	10211822011	2	2	2	2	19600	42000	42000	27799	.2535	34096	1.6613	1.6797
2744	36	10211827010	2	2	2	2	18400	42000	42000	27799	.2535	34096	1.6613	1.6797
2745	36	10211622011	5	5	5	5	20000	20400	34300	27275	.1196	30636	4.5059	56.3419
2746	36	10211422010	5	5	4	5	20450	21200	34100	27781	.1151	31060	4.7328	29.0951
2747	36	10211911011	4	4	4	2	24900	27300	70000	36718	.2032	26673	14.8998	12.5053
2748	36	10211811010	4	4	4	2	24800	27300	70000	36718	.2032	26673	14.8998	12.5353
2749	36	10211811011	4	4	4	2	61400	66700	196800	101270	.2419	65319	16.5597	13.0905
2750	36	10211811010	4	4	4	2	61400	66700	196800	101270	.2419	65319	16.5597	13.0905
2751	36	10211411011	3	3	3	3	65500	81300	94000	70764	.1611	81340	3.3540	2.1917

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE USED FOR MLE LNM	SIZE USED FOR MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
2752	36	10211811010	3	3	3	3	46500	81100	94000	70773	.1612	81306	3.3559	2.1869
2753	37	04011083010	4	4	4	4	6000	7200	9000	6593	.1519	7592	3.7298	2.0965
2754	37	04011083010	4	4	4	4	21000	34000	43000	33494	.1622	37997	4.1580	2.3882
2755	37	04011083010	5	4	4	4	21000	25000	56000	41964	.2367	52422	1.7960	6.3992
2756	37	04011081010	3	2	2	2	40000	76000	76000	65552	.1650	76054	2.2119	1.8951
2757	37	04011083010	4	4	4	4	10000	12000	14000	12157	.0628	12898	8.2263	6.3115
2758	37	04011083010	4	4	4	4	30000	37000	48000	39780	.0965	42576	5.3682	5.4870
2759	37	03211081010	3	3	3	3	9600	9600	13200	10675	.0799	11558	4.8589	VERY HIGH
2760	37	03211081010	4	4	4	4	12000	13800	16200	14020	.0538	14777	8.4010	8.2339
2761	37	03211081010	7	7	7	7	9600	9600	16280	12474	.0878	13637	5.6189	VERY HIGH
2762	37	06411083010	4	4	4	4	5000	5000	7000	5439	.0731	5891	4.9248	VERY HIGH
2763	37	06411083090	3	3	3	3	19000	22000	26000	22150	.0687	23619	6.3689	8.2872
2790	37	04011003010	2	2	2	2	900	1100	1100	995	.0816	1066	6.0324	6.9003
2821	32	00055381011	2	2	2	2	878000	1674000	1674000	1212347	.1982	1422133	2.1246	2.1682
2822	32	00055081010	2	2	2	2	1218000	1867000	1967000	1507981	.1312	1679999	3.2180	3.2457
2823	32	00055084010	2	2	2	2	1783000	1895000	1899000	1830147	.0187	1876151	17.0898	22.7596
2825	36	06411812011	3	3	3	3	1755400	2301000	2067000	1936368	.0376	2000310	14.5033	9.2893
2826	36	06411812010	3	3	3	3	1755400	2001000	2067000	1936368	.0376	2000310	14.5033	9.2898
2850	32	00012383011	2	2	2	2	30000	35000	35000	32404	.0473	33663	8.8963	8.9931
2851	32	00010383010	2	2	2	2	65000	309800	309868	141985	.4795	206797	.8788	.8878
2852	32	00010383010	2	2	2	2	32400	48400	48400	39880	.1233	43732	3.4162	3.4342
2853	69	00056081020	6	6	6	6	1352	1370	2252	1498	.0871	1663	3.7236	82.7125
2854	69	00056081021	6	6	6	6	1343	1362	2246	1488	.0880	1657	3.6773	77.8698
2855	69	00056081020	4	4	4	4	3316	3811	4180	3831	.0451	3991	12.3808	8.2707
2856	69	00056081021	4	4	4	4	3146	3679	4072	3710	.0516	3888	10.9281	7.3525
2857	69	00056081020	4	4	4	4	8566	9569	11546	10011	.0561	10574	8.2723	10.3026
2858	69	00056081021	4	4	4	4	7791	9270	11392	9996	.0668	10642	6.4782	6.6499
2861	69	00056081020	2	2	2	2	2863	5092	5092	4187	.2216	4910	1.8987	1.9288
2862	69	00012081021	2	2	2	2	2856	5858	5858	4887	.2282	4681	1.9822	1.9336
2863	69	00056081020	2	2	2	2	8877	12731	12731	10631	.1107	11622	3.8824	3.8447
2864	69	00012781021	2	2	2	2	8067	12526	12526	10052	.1351	11288	3.1159	3.1585
2865	69	00011081021	2	2	2	2	8468	12260	12260	10189	.1136	11166	3.7851	3.7663
2866	69	00056381020	2	2	2	2	25456	35716	35716	30153	.1040	32787	4.0486	4.0936
2867	69	00012081021	2	2	2	2	20000	32599	32599	25534	.1980	28813	2.8884	2.8376
2868	69	00011081021	2	2	2	2	21000	22805	22805	21804	.0293	22446	12.9645	16.8123
2869	69	00056081020	2	2	2	2	110946	193494	193494	146514	.1700	168123	2.4448	2.4022
2870	69	00012081021	2	2	2	2	101000	181721	181721	135676	.1084	150658	2.3349	2.3682
2871	69	00011081021	2	2	2	2	77000	130358	130358	100190	.1617	114121	2.6842	2.6831
2872	69	00056081020	2	2	2	2	976	1307	1307	1163	.1079	1269	3.9813	3.9447
2873	69	00012081021	2	2	2	2	949	1271	1271	1090	.0897	1181	4.6930	4.7451

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR LNM	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TBS-ALFA)
2874	69	00011081021	2	2	2	2	949	1271	1271	1090	.0897	1181	4.6930	4.7951
2875	69	00056081020	2	2	2	2	8509	17800	17800	12307	.2267	14772	1.0576	1.0703
2876	69	00012081021	2	2	2	2	7500	15850	15850	10903	.2290	13120	1.0323	1.0527
2877	69	00011081021	2	2	2	2	7500	16000	16000	10905	.2344	13266	1.7905	1.8165
2878	69	00056081020	2	2	2	2	30000	79160	79160	48732	.2980	61949	1.4131	1.4280
2879	69	00012381021	2	2	2	2	21925	66999	66999	38327	.3430	90923	1.2274	1.2410
2880	69	00011081021	2	2	2	2	21929	77500	77500	41221	.3070	56331	1.0050	1.0079
2881	69	00056081020	2	2	2	2	103218	116427	116427	109624	.0370	112990	11.3095	11.5120
2882	69	00012081021	2	2	2	2	95837	109000	109000	102207	.0395	105512	10.6532	10.7716
2883	69	00011081021	2	2	2	2	55600	88000	88000	69949	.1410	78360	2.9061	3.0192
2884	69	00056381020	2	2	2	2	1377	1901	1901	1610	.0990	1752	4.2517	4.2909
2885	69	00012081021	2	2	2	2	648	1836	1836	1091	.3190	1411	1.3165	1.3311
2886	69	00011081021	2	2	2	2	897	1836	1836	1283	.2200	1532	1.9141	1.9356
2887	69	00056081020	2	2	2	2	8993	12120	12120	10440	.0916	11240	4.9965	4.6456
2888	69	00012381021	2	2	2	2	8571	11380	11380	9937	.0837	10630	5.0300	5.0050
2889	69	00011081021	2	2	2	2	7564	11999	11999	9527	.1617	10679	2.9716	3.0044
2890	69	00056381020	2	2	2	2	43618	46427	46427	45001	.0192	45904	16.5901	22.2122
2891	69	00012381021	2	2	2	2	36416	43406	43406	39758	.0539	41522	7.0089	7.0951
2892	69	00011381021	2	2	2	2	35800	44000	44000	40239	.0540	42058	7.6728	7.7580
2893	69	00056081020	3	3	3	3	22682	33992	38629	30997	.1207	34437	4.3899	3.0068
2894	69	00056381021	2	2	2	2	29595	38293	38293	33641	.0796	35867	5.2936	5.3522
2895	69	00056081020	3	3	3	3	67309	93770	113209	89400	.1143	99086	4.2309	3.6600
2896	69	00056381021	2	2	2	2	55770	93231	93231	78899	.1025	85690	4.1071	4.1527
2897	69	00055081020	3	3	3	3	76536	107560	109572	95772	.0944	103758	6.1695	3.3165
2898	69	00056381021	2	2	2	2	46975	80331	80331	61429	.1640	70146	2.5556	2.5838
2899	69	00056381020	3	3	3	3	35256	45459	50803	43365	.0816	46620	6.1831	4.7857
2900	69	00056381021	2	2	2	2	36719	50802	50982	42031	.1176	46198	3.5071	3.6260
2901	69	00055381020	3	3	3	3	31680	37020	40160	36114	.0574	37846	9.3091	7.8380
2902	69	00056081020	3	3	3	3	55019	64833	68430	62496	.0493	65249	10.6029	7.4100
2903	69	00056081021	2	2	2	2	39065	65002	65302	50391	.1566	57156	2.5926	2.7225
2940	69	00056381020	2	2	2	2	158	243	249	198	.1397	222	3.0143	3.0670
2941	69	00056381020	2	2	2	2	313	553	553	416	.1748	479	2.4009	2.4357
2942	69	00056381020	2	2	2	2	659	764	764	710	.0454	736	9.2737	9.3767
2943	69	00012381021	2	2	2	2	637	690	690	663	.0246	676	17.1590	17.3456
2944	69	00011381021	2	2	2	2	659	750	750	703	.0397	726	10.5997	10.7176
2971	69	00010383010	3	3	3	3	629100	1429303	1873009	1291686	.2706	1624969	2.1573	1.1398
3000	13	09001865010	6	6	6	6	33000	39303	53000	42999	.0954	47193	5.5900	4.1595
3001	14	09011865010	2	2	2	2	3400	3500	3500	3450	.0089	3482	35.7160	47.8230
3002	14	09011865010	2	2	2	2	6500	7700	7700	7075	.0920	7377	8.0920	8.1827
3003	14	10001865010	2	2	2	2	213000	754309	754009	307920	.3926	545481	1.0726	1.0845

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR MLF LNM	SIZE FOR MLF WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (LOS-ALFA)
3004	16	09001860010	2	2	2	2	16500	17100	17100	16797	.0110	16990	28.9918	38.8121
3005	16	09001860010	2	2	2	2	30100	36200	36200	33009	.0567	34551	7.4299	7.3124
3006	16	09001865010	2	2	2	2	2900	3000	3000	2950	.0104	2982	30.5430	40.8910
3007	16	09001865010	2	2	2	2	14900	15500	15500	15197	.0121	15389	26.2317	35.1149
3008	16	09001865010	2	2	2	2	35000	43400	43400	38974	.0061	41104	6.3737	6.4445
3009	16	09001865010	2	2	2	2	27100	30300	30000	28513	.0512	29239	13.4002	13.6301
3010	16	09001865010	2	2	2	2	73200	75100	75100	74144	.0077	74792	40.3992	54.0990
3011	16	09001860010	3	3	3	3	2300	3000	4000	3022	.1202	3383	3.6371	4.5700
3012	16	09001865010	2	2	2	2	6000	9300	9300	7470	.1346	8325	3.1205	3.1532
3013	16	09001865010	2	2	2	2	21800	25300	25300	23485	.0457	24366	9.2883	9.3106
3014	16	09001865010	2	2	2	2	8700	66500	66500	23352	.0428	39187	.0990	.0623
3015	16	09001865010	2	2	2	2	128500	218700	218700	167639	.1633	191203	2.5783	2.6069
3016	16	09001865010	2	2	2	2	4300	4500	4500	4399	.0140	4463	22.7816	30.4932
3017	13	09001865010	2	2	2	2	25700	25800	25800	25750	.0012	25782	264.6666	356.9789
3018	16	09001865010	2	2	2	2	259200	315500	315500	285968	.0604	300713	6.9793	7.0520
3019	16	09001865010	2	2	2	2	67000	95300	95300	66926	.2171	79712	1.9596	1.9611
3020	16	09001865010	2	2	2	2	2000	6000	6000	2828	.2129	3357	1.9780	2.0300
3021	16	09001865010	2	2	2	2	3000	5700	5700	4135	.1971	4847	2.1361	2.1590
3022	16	09001865010	2	2	2	2	52000	62500	62500	57009	.0565	59662	7.6545	7.5374
3023	16	09001865010	2	2	2	2	61500	71000	71000	66079	.0441	68469	9.5449	9.6513
3024	16	09001865010	2	2	2	2	2800	3100	3100	2946	.0315	3021	13.4705	13.6201
3025	16	09001865010	2	2	2	2	21000	44500	44500	30570	.2306	36809	1.8257	1.8463
3026	16	09001865010	3	3	3	2	49800	80300	161500	96614	.1959	77290	10.0523	8.9189
3027	23	09101860010	2	2	2	2	24000	24100	24100	24050	.0013	24082	247.3286	333.4039
3028	23	09101960010	2	2	2	2	35000	46000	46000	40125	.0039	42931	5.0168	5.0726
3029	23	09101860010	2	2	2	2	62000	74000	74000	67735	.0943	70765	7.7491	7.8392
3030	23	09101860010	2	2	2	2	99300	182000	182000	134231	.1870	156047	2.2918	2.2759
3031	23	09101860010	2	2	2	2	11000	18000	18000	14071	.1512	15694	2.7940	2.8140
3032	23	09101860010	2	2	2	2	25000	36000	36000	30000	.1120	32831	3.7600	3.8010
3033	23	09101860010	2	2	2	2	57000	63900	63000	59925	.0387	61865	10.3525	13.0914
3034	23	09101860010	2	2	2	2	112000	195000	198000	145877	.1423	166240	2.5941	2.6229
3035	23	09101860010	2	2	2	2	257000	298000	298000	279421	.0395	288461	10.6491	10.7676
3036	23	09101860010	2	2	2	2	7000	10000	10000	8367	.1095	9130	3.0040	3.0067
3037	23	09101860010	2	2	2	2	249600	274000	274000	261201	.0294	268279	10.8295	14.4096
3038	23	09101860010	2	2	2	2	657000	741000	741000	697737	.0370	724979	8.6120	11.5221
3039	23	09101860010	2	2	2	2	7000	10000	10000	8367	.1095	9130	3.0040	3.0067
3040	23	09101860010	2	2	2	2	17000	17100	17100	17050	.0018	17082	175.7389	236.3625
3041	23	09101860010	2	2	2	2	38000	44000	44000	40890	.0458	42400	9.3522	9.4561
3042	23	09101860010	2	2	2	2	27000	32000	32000	29394	.0522	30655	8.0899	8.1595
3043	23	09101860010	2	2	2	2	61000	70000	70000	65345	.0423	67600	9.9626	10.0732

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR LKM	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
3044	21	03202060010	4	4	4	4	1680	1950	2470	2047	.0710	2195	6.3060	7.7212
3045	21	03202060010	4	4	4	4	2470	2510	3020	2626	.0408	2745	8.8803	71.6313
3046	21	03202060010	3	3	3	3	2250	2870	3160	2733	.0700	2922	6.7556	6.9070
3047	21	03202060010	4	4	4	4	5500	5700	5890	5711	.0119	5787	37.2332	37.2170
3048	21	03202060010	4	4	4	4	6910	7040	8080	7336	.0303	7575	12.7950	61.7392
3049	21	03202060010	4	4	4	4	10100	10390	11300	10785	.0216	10941	20.0910	50.3563
3050	21	03202060010	4	4	4	4	1610	17120	25900	13363	.4943	19162	1.0210	.4627
3051	21	03202060010	4	4	4	4	44340	55460	58600	53370	.0946	55933	11.0076	5.1623
3052	21	03202060010	4	4	4	4	11530	14350	17500	14090	.0700	15016	6.6695	5.2903
3053	21	03202060010	4	4	4	4	18420	22960	27700	22700	.0720	24463	6.2328	5.6750
3054	21	03202060010	4	4	4	4	27390	33390	37100	33203	.0400	34095	9.8130	5.8395
3055	21	03202060010	4	4	4	4	68480	81270	93810	78737	.0400	81364	16.3095	6.7202
3056	21	03202060010	3	3	3	3	29920	35960	36700	34053	.0409	35500	11.7400	6.6192
3057	21	03202060010	4	4	4	4	54340	57610	69400	60224	.0430	62946	9.5195	19.6925
3058	21	03202060010	3	3	3	3	164050	174800	188200	167967	.0600	177065	8.6106	6.2060
3059	21	03202060010	4	4	4	4	456100	503060	995720	900450	.1520	704956	2.4369	11.7920
3060	21	03202060010	4	4	4	4	87750	99500	124310	103609	.0812	112474	5.8309	45.1956
3061	21	03202060010	4	4	4	4	175390	176040	227690	194769	.0550	206021	7.6777	311.0709
3062	21	03202060010	11	11	11	11	519320	598350	1205360	784000	.1171	896867	3.5839	7.4011
3063	23	09101860010	2	2	2	2	91000	104000	104000	97203	.0410	100550	10.2677	10.3010
3064	23	09101860010	2	2	2	2	132000	254000	254000	183107	.2810	215282	2.0967	2.1100
3065	23	09101860010	2	2	2	2	5000	7000	7000	5916	.1033	6429	6.0768	6.1201
3066	23	09101860010	2	2	2	2	22000	25000	25000	23452	.0393	24205	10.7296	10.8049
3067	23	09101860010	3	3	3	3	99000	145000	171000	130096	.1210	190250	4.1610	3.1075
3068	23	09101860010	3	3	3	3	397000	416000	421000	411202	.0135	416987	30.1567	20.0197
3069	23	09101860010	2	2	2	2	12000	13000	13000	12490	.0246	12812	12.9496	17.5196
3070	23	09101860010	2	2	2	2	15000	24000	24000	19996	.1249	21663	3.3019	3.4193
3071	23	09101860010	2	2	2	2	51000	55000	55000	52962	.0232	54291	13.7265	18.3597
3072	23	09101860010	2	2	2	2	65000	74000	74000	69354	.0908	71615	10.5720	10.6980
3073	23	09101860010	2	2	2	2	153000	280000	280000	200970	.1056	240947	2.2686	2.2930
3074	23	09101860010	2	2	2	2	837000	924000	924000	879425	.0304	907590	10.4776	14.0106
3075	23	09101860010	2	2	2	2	8000	10000	10000	8944	.0605	9452	6.1443	6.2126
3076	23	09101860010	3	3	3	3	26000	40000	40000	39128	.1937	40575	3.0010	1.9040
3077	23	09101860010	4	4	4	4	133000	197000	237000	190705	.1094	210221	5.2969	2.9291
3078	23	09101860010	2	2	2	2	15670	17000	17000	15960	.0364	16471	18.9562	11.0750
3079	23	09101860010	2	2	2	2	18000	26000	26000	21635	.1129	23693	3.7285	3.7699
3080	23	09101860010	2	2	2	2	31000	46200	46000	37762	.1212	41634	3.6761	3.3127
3081	23	09101860010	2	2	2	2	39000	53000	53000	45464	.0942	48867	4.4699	4.5196
3082	23	09101860010	2	2	2	2	51000	5300	63000	61902	.0099	62632	32.0967	42.9714
3083	23	09101860010	2	2	2	2	162000	1000	189900	173118	.0400	178897	10.3276	10.4421

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE USED FOR MLE LNM	SIZE USED FOR MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TBS-ALFA)
3084	23	09101860010	2	2	2	2	213000	752000	752000	400220	.3074	546755	1.0009	1.0990
3085	23	09101860010	2	2	2	2	12000	15000	15000	13616	.0605	14178	6.1463	6.2126
3086	23	09101860010	2	2	2	2	44000	84000	84000	60795	.1906	71338	2.1203	2.1690
3087	23	09101860010	2	2	2	2	53000	65000	65000	58694	.0627	61733	6.7177	6.7926
3088	23	09101860010	2	2	2	2	321000	361000	361000	340613	.0361	353380	8.8238	11.0046
3089	23	09101860010	2	2	2	2	1650	2031	2031	1831	.0630	1927	6.5995	6.6728
3090	23	09101860010	2	2	2	2	3516	4075	4075	3785	.0453	3926	9.2926	9.3956
3091	23	09101860010	2	2	2	2	8000	14000	14000	10583	.1719	12194	2.6580	2.6772
3092	23	09101860010	2	2	2	2	18000	26000	26000	21633	.1129	23693	3.7285	3.7599
3093	23	09101860010	2	2	2	2	32000	34000	34000	32985	.0106	33629	17.0070	22.0668
3094	23	09101860010	2	2	2	2	75000	113000	113000	92060	.1259	101882	3.2449	3.3820
3095	23	09101860010	2	2	2	2	350000	555000	555000	440730	.1416	493970	2.9739	3.0060
3096	23	09101860010	3	3	3	3	18000	23000	23000	21195	.0615	22320	9.5072	6.9626
3097	23	09101860010	3	3	3	3	52000	58000	81000	62513	.1003	68979	3.9689	11.1362
3098	23	09101860010	3	3	3	2	268000	374000	701000	412643	.2121	363753	6.1160	3.6699
3099	23	09101860010	2	2	2	2	9570	15156	15156	12063	.1412	13494	2.9021	3.0152
3100	23	09101860010	2	2	2	2	31000	38000	38000	34322	.0625	36095	6.7361	6.8807
3101	23	09101860010	2	2	2	2	38000	65000	65000	49699	.1649	56755	2.9941	2.9825
3102	23	09101860010	2	2	2	2	100000	104000	104000	101980	.0121	103262	26.0601	35.3660
3103	23	09101860010	2	2	2	2	172000	409000	409000	265232	.2660	320600	1.5828	1.6006
3104	23	09101860010	2	2	2	2	8000	9000	9000	8485	.0362	8736	11.0408	11.7699
3105	23	09101860010	2	2	2	2	33000	43000	43000	37670	.0813	40218	5.1790	5.2376
3106	23	09101860010	3	3	3	3	130000	186000	210000	177535	.1088	194320	4.8682	4.8751
3107	23	09101860010	3	3	2	2	213000	411000	1030000	364207	.1026	340064	2.0099	1.9586
3108	23	09101860010	2	2	2	2	13000	19000	19000	15716	.1165	17263	3.6129	3.6530
3109	23	09101860010	2	2	2	2	51000	56000	56000	53442	.0287	55057	11.0708	14.0225
3110	23	09101860010	2	2	2	2	90000	158000	158000	119248	.1720	137056	2.6362	2.4633
3111	23	09101860010	2	2	2	2	124000	155000	155000	138636	.0685	146582	6.1443	6.2126
3112	23	09101860010	3	3	3	3	9000	9000	10000	9322	.0264	9570	16.6619	VERY HIGH
3113	23	09101860010	3	3	3	3	30000	31000	31000	30663	.0082	30926	64.3986	37.0967
3114	23	09101860010	3	3	3	3	90000	112000	179000	120828	.1472	139363	2.7712	5.5622
3115	23	09101860010	2	2	2	2	16000	16100	16100	16050	.0019	16082	165.4866	222.4995
3116	23	09101860010	2	2	2	2	25000	25100	25100	25050	.0012	25082	257.5296	347.2063
3117	23	09101860010	2	2	2	2	39000	46000	46000	42356	.0587	44121	8.3096	8.3977
3118	23	09101860010	3	3	2	2	62000	71000	273000	69292	.0376	68609	10.1151	8.9761
3119	23	09101860010	2	2	2	2	126000	163000	163000	144444	.0742	153342	5.6721	5.7351
3120	23	09101860010	2	2	2	2	8000	9000	9000	8485	.0362	8736	11.0408	11.7699
3121	23	09101860010	3	3	3	3	29000	32000	36000	32207	.0470	33669	9.1730	12.3567
3122	23	09101860010	3	3	3	3	108000	122000	129000	118895	.0348	121995	16.3356	9.9795
3123	23	09101860010	3	3	3	3	340000	516000	674000	498828	.1490	562219	3.1719	2.9190

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR LNM	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TBS-ALFA)
3124	23	09101860010	2	2	2	2	23000	34000	34000	27964	.1200	30005	3.5078	3.5467
3125	23	09101360010	2	2	2	2	51000	57000	57300	48343	.1012	52447	4.1613	4.2275
3126	23	09101860010	2	2	2	2	50000	62000	62000	55670	.0661	58720	6.3737	6.4445
3127	23	09101860010	3	3	3	3	15000	16000	19000	16583	.0531	17466	7.9527	10.0470
3128	23	09101860010	3	3	3	3	41000	55000	74000	59054	.1282	62056	3.4436	4.1400
3129	23	09101860010	3	3	3	3	131000	171000	190000	162059	.0832	174309	6.1710	4.5640
3130	23	09101860010	2	2	2	2	37000	61000	61000	47508	.1535	53761	2.7426	2.7720
3131	23	09101860010	3	3	2	2	88000	169000	400000	149090	.1010	143294	2.1010	1.8040
3132	23	09101360010	2	2	2	2	455000	616000	616000	529415	.0930	570606	4.5257	4.5700
3133	23	09101860010	2	2	2	2	12000	13000	13000	12490	.0246	12812	12.9634	17.3196
3134	23	09101860010	2	2	2	2	29000	45000	45000	36125	.1349	40272	3.1205	3.1552
3135	23	09101360010	2	2	2	2	77000	94300	94000	85076	.0613	89779	6.8729	6.9092
3136	23	09101460010	4	4	4	2	592000	654000	1777000	872677	.2150	637746	13.7656	11.5536
3137	23	09101860010	2	2	2	2	41000	51000	51000	45727	.0670	48264	6.2020	6.3518
3138	23	09101860010	2	2	2	2	62000	67000	67000	64452	.0234	66063	13.3579	17.8742
3139	23	09101860010	2	2	2	2	155000	797000	797000	352607	.5009	527813	.8406	.8500
3140	23	09101860010	2	2	2	2	166000	501300	501000	268596	.3829	365612	1.0997	1.1119
3141	23	09101860010	2	2	2	2	309000	596000	596000	429143	.2017	504848	2.0872	2.1106
3142	23	09101360010	2	2	2	2	18000	21000	21000	19442	.0473	20190	8.8963	8.9931
3143	23	09101860010	3	3	3	3	38000	132000	140000	88885	.3199	116616	1.9200	.9760
3144	23	09101360310	3	3	3	3	240000	356000	452000	356882	.1729	419425	2.5513	3.0050
3145	23	09101960010	2	2	2	2	39000	131300	131000	71477	.3721	96452	1.1316	1.1642
3146	23	09101360010	3	3	3	2	130000	154000	302000	171258	.2268	140770	3.8641	3.4282
3147	23	09101860010	3	3	2	2	127000	176300	5218000	165750	.0905	162053	4.2019	3.7270
3148	23	09101960010	2	2	2	2	8000	9000	9000	8485	.0362	8736	11.6406	11.7699
3149	23	09101860010	2	2	2	2	15000	21300	21000	18330	.0635	19606	5.0419	5.0879
3150	23	09101360010	2	2	2	2	118000	124300	124300	120963	.0152	122888	20.0837	27.9512
3151	23	09101960010	2	2	2	2	62000	107300	107000	81449	.1676	93218	2.5125	2.5606
3152	23	09101360010	2	2	2	2	228000	278000	278000	251762	.0609	264615	6.9149	6.9918
3153	23	09101860010	2	2	2	2	451000	546000	546000	496232	.0587	520255	7.1726	7.2523
3154	24	09101460010	2	2	2	2	14000	30000	30000	21909	.1931	25596	2.1811	2.2093
3156	19	05902860010	4	2	2	2	163000	244300	244000	251778	.1023	266010	3.6633	3.7827
3157	19	05902860010	44	16	16	16	132000	143000	248000	297814	.1770	312493	3.7506	12.6259
3158	19	05902960010	51	25	25	25	128000	183000	269000	250088	.1163	267025	5.2873	5.6600
3159	19	05902460010	46	10	10	10	134000	180000	250000	351859	.1669	345663	6.4277	3.7389
3160	19	05902360010	56	29	29	29	161000	163300	250000	266079	.0920	299625	6.8007	81.7586
3161	19	05902860010	51	5	5	5	144300	196000	246300	369780	.1299	367736	5.7801	26.2258
3162	19	05902860010	11	3	3	3	171000	173000	235000	313558	.1714	329839	2.9565	90.1526
3163	19	[illegible]	[illegible]	3	3	3	171000	179000	190000	219204	.1125	245307	3.0632	26.6321
3164	19	[illegible]	[illegible]	2	2	2	197000	219300	218300	207236	.0311	214025	10.2291	13.6962

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR MLE LNM	SIZE FOR MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
3165	19 05902960010	5	3	3	3	172000	174000	249000	232719	.1171	255287	3.5112	96.5085
3166	19 05902960010	49	33	33	33	105000	110300	248300	220324	.1439	244240	4.2127	21.7185
3167	19 05902960010	43	29	29	29	139000	139000	248000	227967	.1207	250707	4.5070	VERY HIGH
3168	19 05902960010	46	12	12	12	175006	177000	248000	296519	.1183	302276	5.7178	88.9597
3169	19 05902960010	46	30	30	30	96000	120000	223000	207610	.1581	237660	3.2742	4.5390
3170	19 05902960010	44	8	8	8	161000	170000	250000	356706	.1596	344420	4.7052	10.5786
3171	19 05902960010	13	4	4	4	178000	202000	211000	284225	.1270	302489	3.9582	8.2268
3172	19 05902960010	5	3	3	3	159000	182000	192000	219830	.1118	265531	3.0865	15.0553
3173	19 05902960010	8	5	5	5	159000	199300	240000	230246	.0954	247957	4.8827	4.7605
3174	19 05902860010	53	33	33	33	74000	95000	247000	208111	.2025	245121	2.6509	4.04.
3175	19 05902960010	53	23	23	23	109000	127000	247000	266123	.1566	283413	4.2011	6.6053
3176	19 05902860010	43	33	33	33	101000	113000	248300	222749	.1588	250261	3.6358	8.9324
3177	19 05902960010	52	41	41	41	78000	111300	250000	208122	.1330	231007	4.6830	2.0619
3178	19 05902860010	11	6	6	6	79000	85000	237000	226713	.2987	277209	1.6976	14.3219
3179	19 05902860010	11	6	6	6	149000	166000	239000	236149	.1343	261018	3.5717	9.7038
3180	19 05902860010	11	3	3	3	135000	278000	249000	331906	.1926	326242	3.2221	2.0005
3181	19 05902860010	10	5	5	4	155000	174000	248300	246964	.1203	267720	4.0653	22.3953
3182	19 05902960010	10	7	7	7	112000	134000	249000	212098	.1709	243460	2.9945	5.8749
3183	19 05902960010	10	3	3	3	150000	275000	226000	296838	.1446	305475	3.7018	3.8906
3184	19 05902960010	47	16	16	16	91000	100000	244000	194349	.1621	224543	3.1852	10.7177
3185	19 05902960010	47	26	24	24	117000	126000	249000	249236	.1448	269687	4.3345	13.6396
3186	19 05902960010	47	27	27	27	131000	113300	245300	226494	.1823	258608	3.0989	3.0336
3187	19 05902960010	45	29	29	29	57000	74000	248000	210754	.2353	250036	2.4795	2.6373
3188	19 05902960010	13	7	7	7	163000	173000	248000	244493	.1164	261038	4.8316	5.4538
3189	19 05902960010	13	10	10	10	111000	155300	264000	210327	.1200	231210	4.6236	3.1164
3190	19 05902960010	12	6	6	6	126000	159000	249000	254606	.1573	273067	3.7619	4.1997
3191	19 05902960010	13	6	6	6	159000	171000	228000	250867	.1336	274989	3.6639	14.3313
3192	19 05902960010	13	11	11	11	103000	138000	246300	182784	.1294	207869	3.5545	3.5572
3193	19 05902960010	13	5	5	5	176000	196300	238000	265041	.1090	281240	4.7876	10.6962
3194	19 05902960010	1048	561	561	561	57000	74000	250000	251309	.1755	275332	3.7049	3.8335
3195	19 05902960010	560	222	222	222	96000	105000	250000	271612	.1538	289271	4.3549	11.1694
3196	19 05902960010	513	319	319	319	57000	74000	250000	228292	.1787	256712	3.4311	3.8368
3201	17 19732865010	3	3	3	3	85000	89000	110000	96059	.0597	99778	6.5733	26.4517
3202	17 19732865010	3	3	3	3	92000	129300	137000	113164	.1219	125574	4.6746	2.6945
3203	17 19702865010	3	2	2	2	135000	167300	167000	150705	.0631	158556	6.6771	5.7512
3204	17 19732865010	2	2	2	2	237000	247300	247000	241948	.0127	245154	25.0587	33.5435
3205	17 19732865010	23	20	20	20	122000	145000	216000	184915	.0679	197616	9.1458	5.9197
3206	17 19702865010	15	15	15	15	655000	678000	1060000	858164	.0705	924785	7.3392	29.9964
3240	21 03207060010	4	4	4	4	1270	1290	1480	1352	.0304	1396	13.4760	73.6451
3241	21 03207060010	4	4	4	4	1520	1610	1920	1569	.0433	1747	8.8157	23.0344

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS • UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR LNM	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (FOS-ALFA)
3600	13	09001865050	5	6	6	6	183671	191682	295596	195833	.0181	199531	26.1470	26.0063
3601	13	09001865050	5	6	5	6	332344	341196	1400460	1114707	.0757	1207319	5.9600	115.7716
3602	14	09001865050	6	6	6	6	28070	26245	38015	32166	.0686	33769	10.2309	176.0127
3603	14	09001865050	6	6	5	6	23675	23940	31065	25734	.0638	27077	7.9000	106.3666
3604	14	09001865050	6	6	5	6	21070	22285	30555	25427	.0661	27237	7.0396	23.2511
3605	14	09001865050	5	6	6	6	23608	27049	31277	27771	.0613	28925	11.9666	8.1926
3606	14	09001865050	6	6	6	6	25197	26757	35536	30657	.0541	32186	6.5950	51.7196
3607	14	09001865050	5	6	6	6	96191	98366	119826	102637	.0596	109069	7.5662	551.0309
3608	14	09001865050	5	5	5	6	26123	26123	30593	25965	.0686	27407	8.1766	VERY HIGH
3609	14	09001865050	6	5	6	6	15925	21124	24220	21357	.0673	22671	9.5566	3.0723
3610	14	09001865050	5	[illegible]	5	6	87640	89250	98053	82586	.0182	96352	25.0062	60.0931
3611	14	09001865050	6	5	6	5	65710	70265	92085	79636	.0491	79742	7.6729	21.1961
3612	14	09001865050	5	6	6	6	68776	73920	91965	79619	.0699	83769	8.7067	15.1633
3613	14	09001865050	5	6	5	6	75599	81605	99767	86659	.0608	90331	10.1382	16.5966
3614	14	09001865050	5	6	6	6	77646	76326	98343	78603	.0357	81744	11.4579	47.0482
3615	14	09001865050	6	6	6	6	177769	177639	249654	211356	.0632	225212	7.9570	2772.3920
3616	14	09001865050	5	5	5	6	53243	53148	80391	73635	.0645	78623	7.3901	23.2282
3617	14	09001865050	6	6	6	6	52372	62407	84892	69132	.0946	73495	7.0189	1949.9915
3618	14	09001865050	6	6	6	6	51615	52710	71350	58026	.0510	61460	7.2208	63.9766
3619	14	09001865050	5	6	5	6	66555	69175	95265	69429	.0296	51028	13.4276	11.0970
3620	14	09001865050	6	5	6	6	140245	141890	173215	151470	.0365	157716	10.7695	93.0092
3621	14	09001865050	5	6	6	6	75705	77105	92575	81935	.0413	85770	9.7906	59.6995
3622	14	09001865050	6	6	6	6	79520	93975	119780	98864	.0578	106894	7.8125	6.5497
3623	14	09001865050	6	6	6	6	112700	114135	136570	120922	.0320	125295	12.0900	86.4595
3624	14	09001865050	5	5	6	6	142580	136400	152390	141639	.0224	144971	21.0615	83.2345
3625	14	09001865050	6	6	6	5	354164	366870	502985	419252	.0590	446510	7.4321	31.0382
3626	14	09001865050	6	5	5	6	96560	91315	99995	97360	.0249	96777	17.8673	16.2339
3627	14	09001865050	5	6	6	6	56655	62675	72660	66390	.0436	69265	17.4031	10.7965
3628	14	09001865050	5	6	5	6	117495	124635	165550	144234	.0672	156362	7.5975	10.9432
3629	14	09001865050	6	6	6	5	103040	112005	137040	120465	.0469	126411	10.0322	13.1196
3630	14	09001865050	6	6	6	6	75075	90825	100695	90080	.0434	94681	13.0110	5.7640
3631	14	09001865050	5	6	6	6	57665	76860	97615	82274	.0543	86941	8.4610	8.3719
3632	14	09001865050	5	5	6	6	65555	65905	94185	76963	.0608	82043	7.1659	205.6396
3633	14	09001865050	6	6	6	6	131605	112009	125905	114210	.0309	117948	14.8013	11.2306
3634	14	09001865050	6	5	6	6	96625	101785	175930	108925	.0428	114026	9.0001	20.2399
3635	14	09001865050	6	5	6	6	114310	126385	144900	131996	.0365	136700	16.6397	10.0037
3636	14	09001865050	5	6	6	6	78120	83685	108710	93030	.0634	99368	7.3778	13.0978
3637	14	09001865050	5	5	5	6	74200	76615	100450	82920	.0900	87715	7.5876	34.1566
3638	14	09001865050	6	6	5	6	124880	139265	172060	149998	.0510	157460	9.6362	10.0337
3639	14	09001865050	5	5	6	6	100625	106575	139675	115144	.0521	121943	7.5711	10.0620

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR LNM	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE -BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
3640	14	09001865050	6	6	6	6	113050	139475	165370	145776	.0588	153552	11.2251	5.2078
3641	14	09001865050	6	6	5	6	84490	100520	121590	106002	.0591	112342	8.6895	6.2970
3642	14	09001865050	6	6	6	6	105210	123130	132665	123228	.0759	127198	17.6181	6.9552
3643	17	19702865070	10	10	10	10	93	103	130	109	.0408	114	10.0661	16.3164
3644	17	19702865070	10	10	10	10	99	103	152	125	.0692	136	7.4986	26.6001
3645	17	19702865070	10	10	10	10	76	104	139	115	.0762	124	7.8220	3.3591
3646	17	19702865070	10	10	10	10	67	77	162	112	.1120	125	4.7773	7.5737
3647	17	19702865080	20	20	20	20	100	110	280	173	.1141	196	4.0284	10.7634
3648	21	03202060010	3	3	3	3	332040	374560	413760	371952	.0479	388719	9.5178	10.0969
3649	21	03202060010	4	4	4	4	2023810	4023600	5565740	3867430	.1965	4603194	2.9850	1.6748
3650	4	30006855830	10	10	10	10	15000	18000	28000	20553	.0835	22539	5.2461	5.7788
3651	4	30006855830	10	10	10	10	89000	114300	171300	137607	.0878	149874	6.6583	4.2559
3652	4	30006855830	11	11	6	6	377000	425000	2616000	579279	.1191	508911	5.7656	8.7481
3653	4	30006855830	10	10	10	10	334000	652000	1437000	854005	.1782	1014940	3.1988	1.5751
3654	4	30006855830	10	10	10	10	463000	714000	2481000	1271691	.1885	1556141	2.9863	18.8594
3655	4	30006855830	10	10	10	10	317000	597000	1224000	731998	.1532	848565	3.6987	1.6644
3656	4	30006855830	10	10	10	10	378000	391000	1683000	701934	.2097	884569	2.1432	31.1596
3657	4	30006855830	10	10	10	8	606000	665000	2505000	1007977	.2022	923930	4.9759	11.3664
3658	4	30006855830	10	10	10	5	161000	142000	698000	268613	.2673	160790	12.5834	149.0845
3659	4	30006855830	10	10	10	10	217000	252000	659000	390001	.1450	412012	2.8079	7.0460
3660	4	30006855830	10	10	10	10	185000	252000	704000	413731	.2000	507712	2.6689	3.4089
3661	4	30006855830	10	10	10	7	210000	225300	838000	356711	.2202	288302	5.9887	15.2712
3662	4	30006855830	10	10	10	10	110000	113000	434000	218676	.2378	281678	2.0829	39.1566
3663	4	30006855830	10	10	10	10	223000	242000	386000	295557	.0791	322247	5.7126	12.0096
3664	22	03202055010	4	4	4	4	48400	57630	63380	57074	.0506	59738	10.9972	6.9928
3665	22	03202055010	3	3	3	3	26270	28680	34830	29716	.0627	31584	6.4679	13.8585
3666	22	03202055010	3	3	3	3	210650	235150	318700	250859	.0932	274810	4.2944	11.8556
3667	22	03202055010	4	4	4	4	47090	53660	58570	53679	.0410	55725	13.1927	8.8186
3668	22	03202055010	4	4	4	4	23380	26090	33610	28044	.0688	30011	6.6849	18.4925
3669	22	03202055010	4	4	4	4	186860	199240	209190	199160	.0205	203437	21.5604	17.9388
3670	22	03202055010	4	4	4	4	40490	42540	43170	42190	.0123	42729	36.8699	23.2989
3671	22	03202055010	4	4	4	4	32580	37190	47550	38420	.0882	41250	5.7905	8.6952
3672	22	03202055010	4	4	4	4	240660	285700	347680	298674	.0658	310069	6.7997	6.7876
3673	22	03202055010	4	4	4	4	397590	403900	610410	480185	.0931	527126	4.8116	73.0007
3674	22	03202055010	6	6	6	6	387740	393450	588740	477249	.0935	526042	5.1395	74.8294
3675	22	03202055010	3	3	3	3	26270	28680	34830	29716	.0627	31584	6.4679	13.8589
3676	22	03202055010	4	4	4	4	97330	99550	100250	99169	.0056	99747	78.7985	51.0238
3677	22	03202055010	4	4	4	4	116110	121910	206370	155111	.1391	177876	3.6415	18.0069
3678	22	03202055010	4	4	4	4	177980	189210	195400	188185	.0172	191575	25.6611	18.0078
3679	22	03202055010	4	4	4	4	34500	38330	51770	43114	.0875	46452	5.5453	10.9308

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR LNM	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE -BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
3690	22	[illegible]	6	6	6	6	48120	48370	62900	51968	.0557	55216	6.5050	222.0676
3691	22	[illegible]	6	6	6	6	82600	156680	232370	143066	.1676	166204	3.3636	1.0313
3692	22	[illegible]	6	6	6	6	178440	181710	184190	181775	.0059	182887	75.0863	63.9675
3920	4	[illegible]	20	20	20	19	193000	699000	4700300	1276397	.2237	1442442	2.9132	1.7915
3921	4	[illegible]	20	20	20	20	2282330	3893303	17528000	6296598	.2307	7926079	2.0269	1.9483
3922	4	[illegible]	10	10	10	10	2226000	2664000	4223000	2996228	.0968	3343376	4.3511	10.2912
3923	4	[illegible]	10	10	10	9	12033300	13933300	50278300	19107296	.1955	20015657	3.0009	13.2198
3924	4	[illegible]	11	11	11	9	19082000	33740000	317912000	92522816	.3493	92108110	2.6576	1.8395
3925	4	[illegible]	10	7	7	7	67625000	53952000	516416000	64420136	.5630	99967657	.8567	8.1592
3926	4	[illegible]	11	11	11	11	1154000	1394000	4972000	2163305	.2050	2725165	2.9642	8.6295
3927	4	[illegible]	10	10	10	10	3312000	5200000	26374000	12078611	.3145	15642147	1.7533	2.3356
3928	4	[illegible]	10	10	10	10	14560000	18763000	66429300	34183875	.1920	41993225	2.6867	80.9118
3929	4	[illegible]	10	10	10	10	597000	1330000	6787000	2522628	.3037	3437875	1.6868	1.3153
3930	4	[illegible]	10	10	10	10	2668000	3642000	5864000	4566103	.1124	5091683	5.2976	4.1363
3931	4	[illegible]	10	10	10	10	876000	1156000	3929000	1932672	.1918	2368844	2.6294	3.7988
3932	4	[illegible]	10	10	6	6	1130000	1360000	13771000	2255136	.2075	1896606	3.0159	7.8903
3933	4	[illegible]	10	10	6	5	1559000	3912305	30764300	7407192	.1923	6078640	3.5915	16.3107
3934	4	[illegible]	10	10	10	10	1576000	1573000	5369000	2647603	.1769	3216819	2.6006	11.6502
3935	4	[illegible]	10	10	10	10	1778000	3092000	11716300	5037304	.2603	6656755	1.8309	1.9961
3936	4	[illegible]	10	10	10	10	1976000	4124300	10114000	5664521	.1983	6841372	2.0760	1.3919
3937	4	[illegible]	10	10	10	10	441000	760000	5776000	1914558	.3732	2436389	1.3516	2.6658
3938	4	[illegible]	10	10	10	10	563300	1255300	6397307	1656359	.2323	2116351	1.9520	1.2696
3939	4	[illegible]	10	10	10	10	772300	853000	2403000	1239112	.1966	1554245	2.0763	9.7503
3940	4	[illegible]	9	10	10	9	938700	969300	6758707	1961919	.2632	2020565	3.0002	32.4040
3941	22	[illegible]	6	6	6	6	217960	1827370	2143670	1149373	.4823	1720435	1.4451	.5612
3962	22	[illegible]	6	6	6	6	1151800	1547980	1949860	1584790	.0993	1736510	5.5139	3.5033
3963	22	[illegible]	6	6	6	6	1552890	1757303	2697550	1976511	.0966	2180182	4.3075	3.3361
3966	22	[illegible]	6	6	6	6	676690	788520	1656840	976843	.1467	1132244	2.9765	9.7043
4000	[illegible]	[illegible]	6	6	6	6	6000	6700	8600	6780	.0547	7210	5.8663	33.3619
4001	[illegible]	[illegible]	3	3	3	3	15600	15600	17500	16876	.0544	17815	7.1258	95.6857
4002	[illegible]	[illegible]	3	3	3	3	36100	35700	39100	32995	.0911	35737	5.7360	4.0567
4003	[illegible]	[illegible]	3	3	3	3	95500	83600	138500	102314	.1141	114607	3.6005	36.8973
4004	[illegible]	[illegible]	3	3	3	3	721700	775700	779100	680670	.0999	740617	5.4655	3.0715
4005	[illegible]	[illegible]	3	3	3	3	48000	48500	58200	53616	.0794	58014	4.8839	117.3811
4006	[illegible]	[illegible]	3	3	3	3	[illegible]	136500	186200	161295	.0577	155566	5.6666	23.6601
4007	[illegible]	[illegible]	3	3	3	3	[illegible]	645300	761803	662696	.0556	699330	7.3636	14.2707
4008	[illegible]	[illegible]	3	3	3	3	21300	21700	25600	22314	.0544	23627	7.6715	14.9105
4009	[illegible]	[illegible]	3	3	3	3	83000	91600	104700	96528	.0907	32076	4.7706	5.3375
401	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	124766	.3085	130960	17.3735	69.9904
4011	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	30572	.8553	66624	.3520	.5299

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE USED FOR MLE LNM	SIZE USED FOR MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE -BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TDS-ALFA)
4012	6	03902028010	3	3	3	3	114300	258000	300000	208640	.2261	250863	2.6722	1.6893
4013	6	03902028010	3	2	2	2	10000	258303	258300	131681	.6879	196883	.7367	.5553
4014	6	03902028010	3	3	3	3	4000	5000	7000	5192	.1724	5837	3.6286	5.6912
4015	6	03902028010	3	3	3	3	61300	63000	64000	55761	.0978	60585	5.9576	3.1048
4016	6	03902028010	3	3	3	3	593000	767000	990009	766470	.1313	850244	3.9782	4.7277
4017	6	03902028010	2	2	2	2	416000	614000	614000	505395	.1196	556477	3.5218	3.5609
4018	6	03902021010	3	3	3	3	52000	57000	70000	59261	.0661	63132	6.1298	13.2696
4019	6	03902021010	3	3	3	3	59000	60000	61000	59994	.0072	60447	56.0863	72.3738
4020	6	03902021010	3	3	3	3	139000	159000	268000	176314	.1316	200666	3.0166	9.0685
4021	6	03902021010	3	3	3	3	144000	151000	172000	155938	.0376	161826	10.6963	36.1235
4022	6	03912021010	3	3	3	3	201000	293000	408000	285242	.1538	329631	2.8682	3.5557
4023	6	03902021010	3	3	3	3	324300	366003	659000	380530	.0764	409019	5.6755	11.3365
4024	6	03902021010	2	2	2	2	927000	1395000	1395000	1137176	.1295	1258130	3.3567	3.3023
4025	6	03902021010	3	3	3	3	630000	568000	836300	588854	.1690	676068	2.9198	4.3707
4026	6	03902021010	3	3	3	3	547300	619000	1015009	624150	.2094	759318	2.0960	2.5599
4027	6	03902021010	7	7	7	7	52300	57000	70000	60071	.0396	62698	10.3565	11.7536
4028	6	03902021010	7	7	7	7	139300	146300	248000	173314	.0977	193559	4.0649	21.9521
4029	6	03902021010	5	5	5	6	201000	293300	659000	329459	.1280	373097	4.0651	3.1073
4030	6	03902021010	9	9	8	8	387000	610000	1395000	709485	.1921	872174	2.3272	10.1393
4031	7	03102021010	4	4	4	4	32800	37000	40500	39420	.0790	47812	4.9783	9.5505
4032	7	03102021010	3	2	2	2	63200	66700	66700	64926	.0166	66050	19.2173	25.7196
4033	7	03102021010	3	3	3	3	73300	92600	161200	105650	.1626	123986	2.6566	7.6573
4034	7	03102021010	5	5	3	3	376500	423606	2959800	500031	.0833	499801	6.7877	8.0795
4035	7	03102021010	3	3	3	3	39500	43700	47900	43590	.0419	45326	10.7871	11.7716
4036	7	03112021010	3	3	3	3	23500	59900	84700	51817	.3003	67040	1.8673	1.1159
4037	7	03112021010	3	3	3	3	75100	127500	201400	124471	.2166	151767	2.1092	2.2981
4038	7	03102021010	3	3	3	3	275700	526103	766700	680898	.2267	588801	2.1682	1.8926
4039	7	03102021010	3	3	3	3	813700	966300	1108200	921193	.0709	987855	5.5666	19.2367
4040	7	03112021010	3	3	3	3	25500	36700	41800	34385	.1020	37619	5.0296	3.7355
4041	7	03112021010	3	3	3	3	67290	61603	83100	62216	.1229	66857	3.5266	4.6248
4042	7	03112021010	3	3	3	3	52300	88600	118800	81895	.1805	96324	2.6896	2.3175
4043	7	03112021010	3	3	3	3	207300	269503	299100	255534	.0824	276777	6.2348	4.6107
4044	7	03112021010	3	3	3	3	38100	52600	53100	47308	.0821	50803	7.1089	3.7717
4045	7	03112021010	3	3	3	3	63300	53100	85300	58100	.1511	67311	2.5769	5.9620
4046	7	03102021010	3	3	3	3	115200	121700	148300	127633	.0577	135093	6.8568	22.1509
4047	7	03112021010	3	4	2	2	126600	175100	523400	177820	.1019	161306	4.2276	3.5681
4048	7	03112021010	3	3	3	3	33200	37303	41000	37029	.0459	38627	9.9683	13.4662
4049	7	03102021010	3	3	3	3	61800	63300	58900	67309	.0002	51232	4.0690	34.5015
4050	7	03112021013	3	3	3	3	65700	75906	101900	70423	.1757	82559	2.7187	2.6596
4051	7	03112021010	3	3	4	3	261300	311100	660900	325963	.1414	373239	2.9568	4.8032

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR LNM	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
4052	7	03102021010	3	3	3	3	170500	390200	714300	962213	.3123	481977	1.4878	1.4892
4053	7	03102021010	3	3	3	2	765600	379900	2062333	1146884	.2284	914714	5.0621	4.6735
4054	7	03102021010	12	12	12	12	26500	33200	53100	40273	.0846	44040	5.6610	4.6323
4055	7	03102021010	12	12	12	12	23500	41800	85300	54568	.1635	64563	3.1563	1.8131
4056	7	03102021010	12	12	12	12	45700	52300	201400	97837	.1852	119253	2.9104	7.7482
4057	7	03102021010	13	13	13	13	126600	175100	744700	312765	.2153	397021	2.0260	3.2004
4058	7	03102021010	13	13	13	13	170500	393200	2674530	1088869	.3509	1450972	1.4723	1.2560
4059	2	03102921010	3	3	3	3	85000	99000	109000	97161	.0545	102075	8.7492	7.9783
4060	2	03102921010	3	3	3	3	124000	152300	182000	158815	.0834	162918	5.6854	5.9765
4061	2	03102921010	3	3	3	3	232000	273000	357000	270019	.1237	307811	3.6374	4.0384
4062	7	03102921010	3	3	3	3	506000	618000	643000	591317	.0401	622227	9.7017	5.1594
4063	2	03102923010	2	2	2	2	197000	199300	199000	197997	.0031	198637	102.2778	137.2429
4064	2	03102923010	3	3	3	3	499000	602000	629000	573829	.0534	600908	10.2610	5.4922
4065	7	03102923010	2	2	2	2	664000	1029000	1029000	826593	.1365	921180	3.1290	3.1646
4066	2	03102920010	3	3	3	3	283000	440000	522000	400646	.1390	453041	3.6909	2.6012
4067	46	15601973010	4	4	4	4	64000	56000	97000	77269	.0891	84464	5.0587	37.3957
4068	20	03102021010	10	10	10	10	53000	61003	90009	70051	.0626	74900	7.0925	7.6844
4069	20	03102021010	10	10	10	10	184000	199000	282000	220677	.0630	243216	7.0354	13.4461
4070	20	03102021010	10	10	10	10	457000	498000	1173000	646621	.1134	740287	3.1027	12.2631
4071	58	04002921010	2	2	2	2	180500	201200	201200	190569	.0334	197271	9.5436	12.7608
4072	58	04002921011	2	2	2	2	180400	197300	197300	188061	.0275	194117	11.5699	15.4009
4073	58	04002921010	3	3	3	3	55100	65603	83000	66544	.0893	72877	4.7579	6.9737
4074	58	04002921011	3	3	3	3	55100	65600	68400	62824	.0503	65619	16.7971	6.9797
4075	58	04002921010	4	4	4	4	92700	135700	159900	120011	.1048	133324	4.1626	8.7684
4076	58	04002921011	2	2	2	2	99100	89700	89200	99150	.0004	89103	897.9262	1235.0813
4077	58	04002029010	6	6	6	6	58800	60200	63700	61430	.0122	62216	38.5727	46.4899
4078	58	04002029011	5	5	5	5	29800	62900	64800	44371	.1257	50909	3.6015	2.7990
4079	58	04002029010	6	6	6	6	37900	41000	58600	47609	.0733	51142	6.3368	13.9143
4080	58	04002029011	4	4	4	4	30200	36200	43000	35132	.0639	37565	6.1138	9.2516
4081	58	04002922010	6	6	6	6	22500	24603	40000	27509	.0905	30593	4.0137	13.4948
4082	58	04002922011	5	5	5	5	17000	21600	28000	22577	.0805	24409	6.1401	4.6589
4083	58	04002922010	6	6	6	6	25600	27500	68200	35606	.1536	42476	2.3008	15.2797
4084	58	04002922011	5	5	5	5	24700	24700	64000	34018	.1711	41143	2.1467	VERY HIGH
4085	73	03102021010	20	20	20	20	87000	96000	157000	115782	.0509	123734	7.0469	10.4212
4086	73	03102021010	10	10	10	10	90000	114000	135300	120504	.0513	126290	12.-939	4.4571
4087	72	00031906010	4	4	4	4	3816	3889	5526	4303	.0747	4749	5.3361	86.1137
4088	72	00031906010	4	4	4	4	10000	11300	14830	11895	.0467	12699	7.0193	12.8739
4089	72	00031906010	4	4	4	4	82000	57100	108000	91376	.0582	96907	7.1976	VERY HIGH
4090	72	00001806010	5	5	5	5	118000	130000	162000	202366	.2144	252041	7.1379	11.5201
4091	72	00001806010	4	4	4	4	3939	4095	7325	4752	.1204	5454	2.8708	30.6477

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR LN4	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TBS-ALPHA)
4092	72	00001806010	4	4	4	4	9000	9000	16000	11800	.1367	13516	3.4508	VERY HIGH
4093	72	00001806010	4	4	4	4	254200	499200	579000	429320	.1520	408043	4.4924	1.7948
4094	72	00001806010	4	4	4	4	5000	8000	8000	7113	.1021	7744	6.9076	2.4400
4095	72	00001806010	4	4	4	4	54000	55000	65000	57941	.0369	59600	9.9007	62.7128
4096	72	00001806010	4	4	4	4	325000	431300	457000	408734	.0673	432905	9.6434	4.8768
4097	72	00001806010	4	4	4	4	32000	35000	64000	41976	.1390	48705	2.7276	12.8412
4098	72	00001806010	4	4	4	4	81000	85000	141000	97541	.1080	109692	3.3492	48.3283
4099	72	00001806010	4	4	4	2	178000	270000	619000	358791	.2445	242992	3.2988	2.7619
4100	72	00001806010	5	5	5	5	4000	4595	4000	4876	.0441	5211	6.5846	8.8456
4101	72	00001806010	2	2	2	2	4994	5638	5678	5307	.0371	5460	11.9412	11.4472
4102	72	00001806010	5	5	5	5	10000	11000	19000	13329	.1316	15316	3.2958	11.7062
4103	72	00001806010	4	4	4	4	39300	54000	62000	51093	.0935	56330	6.3462	3.2747
4104	72	00001806010	4	4	4	4	234000	253000	530000	316549	.1600	375134	2.3929	14.7698
4105	72	00001806010	4	4	4	4	2000	4000	5000	3976	.1990	4694	3.9432	1.2590
4106	72	00001806010	4	4	4	4	19000	37000	50000	36041	.1942	42783	3.0740	1.7246
4108	72	00001806010	3	3	3	3	4304	4554	5208	4674	.0425	4871	9.4874	21.9439
4109	72	00001806010	3	3	3	3	5049	5925	6129	5601	.0450	5985	12.2906	7.6329
4110	72	00001806010	4	4	4	4	7000	7000	8000	7483	.0335	7795	14.2607	VERY HIGH
4111	72	00001806010	4	4	4	4	8900	9000	13000	10079	.0936	11062	4.6810	9.7699
4112	72	00001806010	4	4	4	4	18000	21000	32000	22713	.1060	25412	3.6004	7.4650
4113	72	00001806010	4	4	4	4	37000	41000	54000	45430	.0796	49093	6.8993	11.2846
4114	72	00001806010	4	4	4	2	125000	139000	412900	187049	.2355	135321	12.9150	10.8995
4115	72	00001806010	4	4	4	4	366000	421000	465000	417735	.0430	435093	11.2760	8.2195
4116	72	00001806010	3	3	3	3	658000	513000	661060	537520	.0816	581917	4.9614	10.7260
4117	72	00001806010	4	4	4	4	3814	4202	5601	4503	.0067	4905	5.5031	7.6336
4118	72	00001806010	4	4	4	4	8000	9000	11000	9434	.0595	10000	7.7252	9.7699
4119	72	00001806010	4	4	4	4	17000	22000	33000	23329	.1189	26311	3.5349	4.4636
4120	72	00001806010	4	4	4	4	48000	52000	100000	63940	.1434	74325	2.7446	14.3764
4121	72	00001806010	4	4	4	3	759000	454000	1096000	575560	.2602	484237	2.7292	2.0502
4122	72	00001806010	10	10	10	4	355000	421300	1449300	617764	.2132	461719	9.2490	7.5250
4180	72	00001806010	4	4	4	4	15	71	630	154	.6174	276	.9177	.4443
4181	72	00001806010	3	3	3	3	1002	1375	1602	1336	.0859	1444	5.5336	5.0799
4182	72	00001806010	4	4	4	4	1600	1864	2055	1885	.0375	1952	13.4907	11.0720
4183	72	00001806010	4	4	4	4	2428	2545	2909	2625	.0392	2737	9.5320	24.4909
4184	72	00001806010	5	5	3	3	195	405	1260	405	.1061	374	3.1396	1.5264
4185	72	00001806010	4	4	4	4	642	858	1190	885	.1060	978	4.4205	3.9670
4186	72	00001806010	4	4	4	4	1359	1691	2010	1691	.0708	1808	6.9413	5.2640
4187	72	00001806010	4	4	4	4	1960	2590	3553	2741	.1119	3047	4.4570	4.8835
4188	72	00001806010	4	4	4	4	492	683	974	690	.1329	795	3.4017	5.6564
4189	72	00001806010	4	4	4	4	897	990	1296	1075	.0713	1194	6.2000	11.6640

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR LNM	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
4190	72	00001430010	4	4	4	4	1369	1495	1605	1490	.0316	1534	16.0635	11.1979
4191	72	00001430010	4	4	4	4	1649	2102	2715	2169	.0886	2362	5.3361	4.0000
4192	72	00001406010	4	4	4	4	2110	2161	2751	2411	.0413	2962	7.7799	48.1816
4193	72	00001406010	4	4	2	2	9	10	442	10	.0331	19	13.0130	10.9218
4194	72	00001406010	4	4	4	4	428	440	871	946	.1427	436	2.6404	41.6154
4195	72	00001406010	4	4	4	4	303	677	765	576	.1865	672	3.9968	1.4314
4196	72	00001406010	4	4	4	4	928	1000	1310	1079	.0451	1154	6.3089	15.3098
4197	72	00001406011	4	4	4	4	1718	1759	7013	1857	.0338	1920	13.7862	48.7913
4198	72	00001406013	4	4	4	4	2707	3261	3991	3300	.0694	3533	6.6151	6.1316
4199	72	00001406010	3	3	3	3	66	303	373	107	.6033	279	1.4095	.8141
4200	72	00001430013	4	4	4	4	25	191	449	164	.5669	271	1.0626	.5559
4201	72	00001430010	4	4	4	4	490	738	895	768	.0479	800	8.0973	17.1106
4202	72	00001406010	4	4	4	4	519	1384	1660	1331	.1121	1471	5.1678	2.8104
4203	72	00001406013	4	8	8	8	20	25	286	131	.4787	233	1.4605	4.7873
4204	72	00001430010	3	3	3	3	261	293	293	282	.0790	289	20.1909	10.5177
4205	72	00001406010	4	4	4	4	557	721	867	706	.0769	757	6.8037	4.6589
4206	72	00001406013	4	8	8	8	1000	1303	2030	1283	.1096	1452	3.5675	VERY HIGH
4207	72	00001406013	4	4	4	4	1287	1710	1836	1677	.0695	1726	9.6365	4.0356
4208	72	00001430013	7	7	7	7	10	51	3908	595	1.0078	1513	.5362	.0623
4209	72	00001430013	1	4	4	4	6	8	3295	10	.1304	9	5.0850	3.7133
4210	72	00001430013	5	5	5	5	118	1113	3335	1132	.5765	1869	1.1227	.6972
4240	[illegible]	[illegible]	3	1	3	3	1878100	2657500	2764100	2331005	.0847	2512029	6.0302	4.5232
4241	[illegible]	[illegible]	4	4	3	3	2293400	4161703	7162703	6097065	.7440	5152202	1.9C72	2.0619
4242	[illegible]	[illegible]		4	4	4	3376300	5172700	6167303	5022915	.1918	5786396	2.9620	1.3738
4243	[illegible]	[illegible]	1	1	1	1	430000	1996300	7960000	1912951	.7760	3050598	.6075	.5763
4244	[illegible]	[illegible]		3	3	3	4111330	13921900	23230000	12285917	.2901	16033222	1.5805	1.6150
4245	[illegible]	[illegible]	3	2		2	3065330	5555303	5555000	3370656	.3069	4815667	1.3720	1.3873
4246	[illegible]	[illegible]				2	2376000	7162900	7162000	4037616	.3521	5340689	1.1960	1.2393
4247	[illegible]	[illegible]		4	4	4	3065030	3376300	7162000	4546937	.2872	5962017	1.5195	10.4252
4248	[illegible]	[illegible]		2		2	514503	1163503	1160503	1656866	.5107	2786194	.5157	1.6356
4251	[illegible]	[illegible]	3	3	3	3	1964700	2190500	8863700	2571629	.1662	3076179	7.3707	11.8760
4252	[illegible]	[illegible]					2091660	2505303	2674539	2606659	.0564	2579056	9.2295	5.5651
4253	[illegible]	[illegible]		3			418300	4041900	6278103	1529696	.5751	3163071	1.0155	.5551
4254	[illegible]	[illegible]		2		2	12607600	13068100	15062103	15504560	.1271	17175233	3.3136	3.3506
4255	[illegible]	[illegible]	4	4	4		553700	1158800	2867300	1713152	.2676	1120252	2.9581	1.5681
4256	[illegible]	[illegible]		1		1	573600	1817103	2603150	1513799	.2167	1669791	2.0576	2.6685
4257	[illegible]	[illegible]					1711600	5572103	5922303	6319913	.3144	5400155	1.1271	1.0721
4258	[illegible]	[illegible]				2	3332100	3372300	8151003	3127767	.1162	3038678	3.2791	2.9839
4259	[illegible]	[illegible]	12	12	12	12	413303	744600	4275103	1713260	.3181	2396124	1.5059	1.0323
4260	[illegible]	[illegible]	11	4		4	1711630	2125103	19068100	9677309	.5307	16365606	.8636	6.8626

LIST OF SALIENT FEATURES OF DATA GROUPS TO ESTIMATE SHAPE PARAMETERS									UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS				
ITEM [illegible]	[illegible] TITLE	[illegible]	NUMBER FAILED	SIZE FOR LNM	USED WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE -BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TGS-ALFA)
[illegible]	[illegible]	[illegible]	3	[illegible]	3	615000	1898000	2297300	1368434	.3090	1809349	1.0205	1.0796
[illegible]	[illegible]	[illegible]	4	[illegible]	4	1711000	1448303	2531300	2081087	.0769	2244121	6.1270	11.6706
[illegible]	[illegible]	[illegible]	3	2	3	1337000	3235000	3295000	2141664	.2664	2050191	1.5912	1.6009
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	5515000	6500303	6530303	4793551	.1322	5578217	2.2650	1.9971
4271	[illegible]	[illegible]	[illegible]	[illegible]	3	744300	1331333	1962003	1762316	.1986	1515570	2.2986	2.6253
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	1150200	1256000	1286000	1729257	.0296	1262299	15.0062	13.7960
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	4571600	6149380	7098000	5855060	.0978	6386888	5.1641	6.3163
4274	[illegible]	[illegible]	10	10	7	1239000	1345300	5847003	2069160	.2160	1696796	6.3961	12.8360
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6	4377000	3529000	57350000	4767468	.0611	4069272	10.1595	20.6361
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20	655000	776000	1664306	1018739	.0960	1160757	6.1164	6.1657
[illegible]	[illegible]	[illegible]	11	[illegible]	16	574000	979309	1367000	1064104	.0669	1146655	4.5817	VERY HIGH
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	67	70	140	95	.0990	106	6.6397	26.3535
[illegible]	[illegible]	[illegible]	11	11	[illegible]	79	95	197	111	.1022	124	3.2879	5.7126
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	76	78	178	99	.0840	109	5.9029	20.0139
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	77	80	99	88	.0686	93	10.5905	29.1311
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	63	67	126	86	.1070	96	6.3939	17.1157
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	76	115	156	124	.0896	136	7.1232	2.3899
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	65	72	133	94	.1001	105	6.5866	10.3013
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	76	85	90	85	.0786	87	21.2305	9.9591
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	66	110	153	123	.0617	132	7.3170	7.7396
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	59	143	89	.1223	102	3.0598	VERY HIGH
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	65	67	140	80	.1035	90	3.2670	34.7663
4311	[illegible]	[illegible]	[illegible]	5	5	76	78	102	83	.0920	89	6.7865	28.4672
4312	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	83	86	169	107	.1079	121	3.7238	11.3565
4313	[illegible]	[illegible]	[illegible]	[illegible]	5	82	88	143	107	.0887	118	6.7267	6.2593
4314	[illegible]	[illegible]	[illegible]	[illegible]	10	66	78	111	93	.0648	99	8.3090	7.6793
4315	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	68	82	117	98	.0829	95	5.3686	5.9597
4316	[illegible]	[illegible]	10	[illegible]	10	81	111	196	129	.0991	145	6.6292	3.3659
4317	[illegible]	[illegible]	[illegible]	[illegible]	10	78	82	159	104	.1160	119	3.6986	21.0577
4318	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	67	88	155	120	.0853	131	5.8675	92.1996
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	99	121	208	158	.1214	178	6.7075	3.6307
[illegible]	[illegible]	[illegible]	[illegible]	7	7	4653000	11576300	16687303	13066200	.0986	14996576	5.3563	3.5957
[illegible]	[illegible]	[illegible]	[illegible]	7	7	3636000	5682000	10634300	6962267	.0986	7779002	3.7283	76.3087
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7972000	19370300	5793357	.1563	11712101	7.3366	6.1378
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6491300	9013009	6130901	.1160	6021430	3.6977	12.0663
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12517303	31709009	17619097	.1537	20860116	2.6607	13.7916
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5591303	7764333	5275660	.3062	5895891	3.9863	5.6113
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	23109009	65613009	36606467	.0632	37781630	5.6935	36.5219
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	66000	61003	81669	56500	.0614	90510	9.6961	5.0752
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	36600	65900	70600	68036	.1653	96170	2.8309	5.2656

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR MLE LNM	SIZE FOR MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE -BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (FOS-ALFA)
5302	31	00053083011	3	3	2	2	20000	38700	130000	34276	.1031	32751	2.0770	1.0427
5303	31	00053383011	2	2	2	2	175400	800300	830300	374493	.4660	545267	.9093	.9195
5304	32	00050383011	3	3	3	3	85400	369500	960000	224335	.3571	303692	1.6362	.8563
5305	31	00050383010	3	3	3	3	53800	65803	67800	62146	.0546	65110	10.3700	8.8613
5306	31	00050389010	3	3	3	3	31400	51800	58800	45760	.1633	41824	3.7020	2.4495
5307	31	00050089010	3	3	3	3	56300	57400	62500	63500	.0907	70125	3.9563	21.9991
5308	32	00050389010	3	3	3	3	99300	164400	180090	137663	.1319	154921	3.7206	3.1302
5309	32	00050383010	3	3	3	3	49600	339600	343400	222620	.3438	247997	1.0941	.9116
5310	34	00037084090	2	2	2	2	177000	742000	742000	362400	.4401	516572	.9586	.9573
5311	61	00037387021	3	3	3	3	552000	381000	1192000	833804	.1605	971461	2.0153	2.6310
5312	61	00032387021	6	6	6	6	241000	515000	1120000	557720	.2776	727006	1.7253	1.4430
5313	61	00032387021	7	7	7	7	670000	675000	1480000	954904	.1239	1090451	3.5520	145.1322
5314	61	00032387020	5	5	5	5	776000	800000	1930000	1040227	.1607	1244366	2.2298	33.7600
5315	60	00032387020	2	2	2	2	3480	3560	3560	3510	.0080	3542	36.3354	40.0956
5316	60	00032387020	2	2	2	2	4692	6451	6451	5502	.0970	5952	4.3064	4.3563
5317	60	00032387020	2	2	2	2	5535	8336	8336	6793	.1298	7517	3.3482	3.3054
5318	60	00032387020	2	2	2	2	7113	13503	13500	9799	.1960	11402	2.1907	2.1635
5319	60	00032387020	2	2	2	2	7270	8463	8463	7817	.0480	8130	8.6312	8.7271
5320	60	00032387020	2	2	2	2	9000	11790	11790	10301	.0829	11012	5.0775	5.1330
5322	60	00032387020	4	4	4	4	13752	29115	77539	31799	.3596	44807	1.3417	1.1952
5323	60	00032387020	2	2	2	2	95618	102738	102738	99114	.0221	101607	14.4265	19.3021
5324	60	00032387020	3	3	3	3	76606	148742	148742	119226	.1664	137290	3.5121	1.8332
5325	60	00032387020	2	2	2	2	89581	159977	159977	119712	.1781	138173	2.3644	2.3900
5326	60	00032387020	4	4	2	2	23414	28970	91909	29235	.0802	27601	7.1563	6.8863
5327	60	00032387020	3	3	2	2	32645	47183	147605	64093	.1022	62985	3.7223	3.3024
5328	60	00032387020	2	2	2	2	178702	201131	201131	189585	.0363	195211	11.5959	11.7247
5329	60	00032387020	2	2	2	2	225652	288695	288695	255033	.0757	271069	5.3605	5.6229
5330	62	00032381021	2	2	2	2	590978	864057	864057	708518	.1219	781602	3.6542	3.4926
5331	62	00032381021	2	2	2	2	1060000	1235581	1235581	1144428	.0471	1180644	8.9653	9.0646
5332	62	00032381021	2	2	2	2	602753	1123647	1123647	822971	.1913	960027	2.2016	2.2290
5333	62	00032381021	2	2	2	2	485000	499300	499300	487498	.0019	488458	167.5350	225.2721
5334	62	00032081021	2	2	2	2	211387	910469	910469	440627	.4511	633667	.9353	.9637
5335	62	00032081021	2	2	2	2	939200	961200	961200	950136	.0071	957173	64.7005	90.0726
5336	62	00032081021	2	2	2	2	516053	995880	995800	718275	.2007	846206	2.0970	2.1212
5337	62	00032081021	2	2	2	2	265265	298300	298000	270339	.0598	283605	7.0379	7.1157
5338	62	00032381021	2	2	2	2	164363	164563	164563	164463	.0004	164520	830.0509	1139.9705
5339	62	00032381021	2	2	2	2	163070	163279	163279	163170	.0006	163235	725.0461	902.3787
5340	62	00032381021	2	2	2	2	93712	152650	152650	119604	.1490	136944	2.0100	2.0612
5341	62	00032381021	2	2	2	2	78120	117541	117541	95824	.1295	108813	3.3560	3.3035
5342	62	00032081021	2	2	2	2	251799	292701	282701	266003	.0356	274552	11.0441	11.9757

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	AFF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR LNM	USED MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (VBD-ALFA)
5343	62	00002081021	2	2	2	2	170632	195534	195534	182650	.0418	180918	10.8647	10.1700
5344	62	00012081021	2	2	2	2	171271	171671	171671	171371	.0004	171436	865.9770	1187.0998
5345	62	00072041021	2	2	2	2	227023	285000	285000	254365	.0699	269003	[illegible]	[illegible]
5346	62	10032081021	2	2	2	2	206448	238446	238446	220794	.0472	229356	8.912	9.0110
5347	62	10032081021	3	3	3	3	75670	91600	93760	85706	.0575	90100	9.9675	5.4400
5348	62	00002041021	3	3	?	3	42000	50500	82500	55939	.1516	64870	2.6665	6.0000
5349	62	00032081021	2	2	-	2	38830	39830	39830	39327	.0078	39647	48.7092	34.5200
5350	62	00002061021	2	2	2	2	40275	76550	76550	67927	.0734	72064	5.7360	5.7997
5351	62	00032041021	2	2	2	2	56740	82200	82200	68294	.1138	74091	3.6980	3.7909
5352	63	00002091021	13	13	13	13	91700	169600	897700	209540	.2494	302130	1.6696	1.6096
5353	63	00032081021	10	10	10	10	189000	219100	813900	479560	.2396	609165	2.4275	7.3949
5354	63	00032181020	10	10	10	10	258630	685200	1066500	705689	.1930	867183	3.2111	1.6763
5355	65	00052187051	5	5	5	5	559829	594000	796752	663273	.0508	704615	7.6253	20.0560
5356	65	00052087050	6	6	6	6	719709	751096	1146698	883061	.0727	954703	5.6429	25.6257
5461	31	00050189011	2	2	2	2	944900	1396000	1396000	1148512	.1199	1264902	3.9130	3.9520
5462	31	00050189011	2	2	2	2	1023900	1612200	1612200	1284006	.1394	1437477	3.0201	3.0526
5463	32	00050089011	3	3	3	2	1275300	1690000	3282200	1917797	.2129	1566771	6.9766	6.6196
5464	32	00050089011	4	4	4	2	1128000	1424900	3718500	2166666	.2719	1343029	5.8679	6.9249
5465	31	00050089010	2	2	2	2	1060300	1534300	1534300	1263381	.1193	1398020	3.5205	3.9677
5466	31	00050089010	3	3	3	2	1625600	1987100	4639200	2665427	.2417	1880796	6.0200	6.0578
5467	31	00050089010	2	2	2	2	1631600	2201800	2201800	1895378	.0920	2041214	4.5766	4.6296
5468	32	00050089010	3	3	3	2	1287900	1680400	3060200	2029091	.2487	1570947	5.1540	6.5726
5469	32	00050087010	4	4	4	4	1150130	1859800	3729900	2341665	.2464	2962550	2.0598	2.4742
5470	39	03202088090	2	2	2	2	6450000	23000000	23000000	12179901	.3905	16680481	1.0704	1.0006
5471	41	00032347021	4	2	2	2	2520000	3670000	3670000	20762211	.9143	46693842	.3109	3.0610
5472	61	00002087020	2	2	2	2	3565900	4560000	4560000	4031923	.0756	4205015	5.5608	5.6317
5473	61	00002387020	2	2	2	2	991000	1671000	1671000	1207370	.1213	1331278	3.4712	3.5390
5474	60	00002387020	4	4	4	2	1969247	2335040	6265514	3293804	.2302	2237222	8.0310	6.7606
5475	60	00002087020	4	4	4	3	553694	834034	2327100	1050634	.2632	929674	2.9629	2.0893
5476	60	00002387020	4	4	4	4	2275045	2567198	3162498	2667250	.0596	2832104	7.1423	9.5247
5477	60	00032087020	2	2	2	2	2306842	5390408	5390408	3560920	.2502	4307585	1.6830	1.7017
5478	60	00002387020	4	4	4	4	2983567	3086375	5140101	3780061	.1102	4195909	3.7172	34.0640
5479	60	00032087020	4	4	4	4	1643195	3129757	4654378	3027864	.2260	3705444	2.5624	1.4065
5480	63	00032087020	2	2	2	2	10491473	10551123	10551123	10521296	.0010	10540365	191.7603	244.5195
5481	61	00032341021	13	13	13	13	232700	270800	1610700	816082	.2675	1062394	2.1705	4.8524
5482	63	00032381021	9	9	9	9	964100	1161900	4697700	2204558	.2271	2087570	2.0606	5.6000
5483	63	00032341620	10	10	10	10	1276800	2385400	6496500	2931776	.2045	3699986	2.1770	2.1607
5701	34	04002921011	3	3	3	3	102200	113000	151500	120498	.0888	131463	6.6905	12.1007
5702	34	04002921010	3	3	3	3	116000	127600	159000	133015	.0702	142631	5.7964	12.7625
5704	36	04002921011	3	3	3	3	49100	65200	107800	70143	.1730	82870	2.3866	4.2091

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

[illegible] DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR LNW	USED FOR WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	56100	67600	108000	78515	.1201	88473	3.2290	47.9019
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	55900	77800	99900	73122	.1058	80306	6.7815	3.5796
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	58900	78200	96700	76196	.1096	84227	4.2397	4.3913
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	172800	177900	241300	202503	.0733	217775	6.3286	39.5620
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	172800	176000	241300	202532	.0732	217791	6.3341	38.8121
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	106100	142600	243800	167500	.1709	197291	2.9067	3.6567
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	109700	142500	243800	169126	.1634	198099	2.9090	4.1586
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	137700	186200	255900	205807	.1436	236705	3.2506	3.9551
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	137700	206300	299800	215679	.1452	267003	3.5290	2.7999
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	63900	134800	247600	142966	.2553	180588	2.1601	1.5416
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	63500	137503	175600	161079	.3223	220627	1.4217	1.5317
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	180100	210603	276300	218766	.0961	239524	4.3920	7.8226
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	184600	219603	281700	223909	.0893	244374	4.4769	11.5683
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	55200	52200	76100	56578	.1098	63010	3.6306	9.9621
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	65700	73100	67600	69635	.1580	74883	3.3915	7.2521
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	136700	166300	213500	161817	.1595	185746	3.6165	7.1980
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	123100	231503	2[illegible]5700	177564	.1400	200360	3.9213	7.4684
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	65800	73830	227400	67520	.1762	65704	2.8340	2.5151
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	62500	83600	229600	79266	.0807	77668	4.7135	4.1918
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	41200	41400	[illegible]	90568	.3258	125758	1.6703	230.3953
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	106000	223300	134238	.1466	157436	2.6606	14.9966
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	111970	126003	216303	159901	.1235	174932	3.6226	9.3311
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	140300	253900	198959	.0673	217092	5.3836	6.2102
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47600	72900	139600	111165	.0832	121178	5.3567	206.7623
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	135600	115914	.0648	126949	7.0406	38.7974
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	258600	121060	.2348	90989	4.4896	8.6063
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	127033	.2538	94733	6.3047	4.6363
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	68800	121400	90437	.1421	102781	3.4071	2.9694
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	109000	126530	95379	.1546	109331	3.3011	2.6806
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	137600	117700	90995	.1610	106435	3.3155	2.0532
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	104600	122300	93894	.1579	107514	3.5311	2.1620
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	76701	[illegible]	72878	.0963	72299	4.0359	3.5001
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	73600	69276	.1560	67378	2.5632	7.5536
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	62258	.3055	62534	76.4687	66.0109
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47703	[illegible]	43617	.3143	44069	28.3399	259.0917
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	63039	.0262	86672	10.3363	32.8672
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	63629	.0309	65623	14.3676	28.8123
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	63136	.2150	77314	2.0316	2.5607
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	86471	.2441	97646	1.9586	1.8035
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1760	[illegible]	72172	.1423	77080	2.3516	2.5622

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM NO.	[illegible]	SAMPLE SIZE	NUMBER FAILED	SIZE USED FOR MLE LN	SIZE USED FOR MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
5745	[illegible]	[illegible]	6	[illegible]	2	25500	27500	142300	27599	.0237	26980	10.1579	15.2399
5746	[illegible]	4	6	6	6	15900	20100	26600	20921	.0813	22723	5.1117	6.6363
5747	[illegible]	6	6	6	6	25000	25500	37800	28560	.0831	31244	6.6244	48.5201
5748	[illegible]	[illegible]	[illegible]	[illegible]	3	66500	76800	127900	85932	.1542	99962	2.5852	7.0316
5749	[illegible]	[illegible]	[illegible]	[illegible]	3	66600	88800	139300	92797	.1677	108994	2.5194	3.8231
5750	[illegible]	6	6	6	6	21300	37500	58300	38428	.1917	45452	2.7627	1.9846
5751	[illegible]	6	6	6	6	21300	37500	58700	38635	.1937	46183	2.7397	1.9946
5752	[illegible]	[illegible]	[illegible]	6	6	42300	43500	58200	48766	.0682	52168	6.5537	32.7926
5753	[illegible]	6	6	6	6	42000	44500	58200	49024	.0659	52358	6.7983	19.9021
5754	[illegible]	[illegible]	6	[illegible]	[illegible]	33600	44800	115300	54055	.2298	65171	6.3353	4.0963
5755	[illegible]	[illegible]	6	6	[illegible]	34600	49900	116300	55755	.2263	57411	6.0028	3.0987
5756	[illegible]	6	6	[illegible]	2	49000	53200	172200	81730	.2557	57106	16.6719	13.9926
5757	[illegible]	6	6	6	2	69800	54500	172900	83960	.2568	53465	16.8998	12.5355
5758	[illegible]	[illegible]	6	6	[illegible]	68000	93700	240300	108452	.2909	100949	2.3006	1.7203
5759	[illegible]	[illegible]	6	6	[illegible]	69700	96500	240300	110465	.2842	102933	2.3766	1.7342
5760	[illegible]	6	6	[illegible]	2	33300	50400	269300	51018	.0806	47233	5.3667	4.6875
5761	[illegible]	[illegible]	6	[illegible]	[illegible]	33300	50400	258300	51018	.0806	47233	5.3667	4.6875
5762	[illegible]	[illegible]	[illegible]	[illegible]	3	36600	63600	65000	46776	.2413	57339	2.4197	1.2764
5763	[illegible]	[illegible]	[illegible]	[illegible]	3	26600	63900	68600	47573	.2486	58767	2.3293	1.2764
5764	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	56700	83600	116100	82866	.1661	96148	2.9575	2.4569
5765	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	56700	89600	116100	82266	.1661	96148	2.9575	2.4669
5766	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	102500	108900	133500	114221	.0601	121177	6.5962	23.0536
5767	[illegible]	[illegible]	[illegible]	[illegible]	3	102500	108900	133500	114221	.0601	121177	6.5962	20.0936
5768	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	97000	226700	245000	175820	.2242	212749	2.5799	1.6182
5769	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	97000	245000	265300	179978	.2325	219192	2.5135	1.3128
5770	[illegible]	[illegible]	[illegible]	[illegible]	6	49900	51600	92400	60168	.1256	68974	2.8963	38.0536
5771	[illegible]	[illegible]	6	[illegible]	2	52300	59000	685000	69336	.0321	67742	13.6227	11.2656
5773	[illegible]	[illegible]	[illegible]	6	6	77600	150400	214400	148911	.1990	177882	2.9132	1.7458
5774	[illegible]	[illegible]	[illegible]	[illegible]	6	45500	212000	218000	179665	.2200	217397	2.8069	1.2672
5775	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	55500	57700	121600	81805	.1491	96893	2.5980	68.0150
5776	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	73000	74500	127600	89273	.1362	102004	2.8956	25.9760
5777	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	127500	181300	274600	146766	.1675	216325	2.5816	3.6331
5778	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	129600	187600	274600	198094	.1632	219096	2.5975	3.2946
5779	[illegible]	[illegible]	[illegible]	6	6	14900	33200	50500	33669	.1814	39590	2.8569	2.0625
5780	[illegible]	[illegible]	[illegible]	6	6	33200	37500	50500	39723	.0765	43030	5.1385	9.6686
5781	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28600	33500	56500	48390	.1966	60166	2.2253	16.2377
5782	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	31200	36300	56600	51767	.1814	63298	2.4187	53.9552
5783	[illegible]	1[illegible]	1[illegible]	1[illegible]	10	36700	35000	102200	46090	.1455	57262	2.6256	122.3933
5784	[illegible]	1[illegible]	1[illegible]	1[illegible]	10	43300	62300	102200	52524	.1210	60696	2.7866	21.7527
5785	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	56600	42300	136501	87202	.1861	106000	2.7866	1.5361

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS									UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS				
ITEM	FFE DESCRIPTION	SAMP. NO. (S)	NUMBER FAILED	SIZE USED FOR MLE LNM	WBL	FIRST FAILURE (FF1)	SECOND FAILURE (FF2)	LAST FAILURE (FFNF)	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
5696	37 0403241201 3	3	3	3	3	57600	90000	167800	94167	.1624	114245	2.7176	3.2755
5697	36 0403241201 1	4	4	4	4	157200	219300	268600	216810	.0863	237223	5.0210	4.2530
5698	36 0400341201 0	4	4	4	4	159500	274400	270600	221317	.0840	239533	5.9566	4.1313
5699	36 0403241201 1	8	8	8	8	17600	24000	77200	39940	.2012	49260	2.4320	5.2767
5700	36 0400381201 0	8	8	8	8	21200	25300	72200	41449	.1918	50568	2.5952	6.0423
5701	36 0403241201 1	4	4	4	4	20300	23300	27400	23516	.0535	24630	7.6294	9.2152
5702	36 0400341201 0	4	4	4	4	21000	23900	27400	23514	.0482	24734	8.2806	12.6603
5703	36 0403241201 1	4	4	4	3	23000	46800	90800	47363	.2447	44854	2.9336	1.6190
5704	36 0403341201 0	4	4	4	3	23300	46800	91200	47572	.2431	44967	3.0250	1.6580
5705	36 0403251201 1	4	4	4	2	52500	73800	172000	101185	.2515	67708	4.0261	3.3791
5706	36 0400241201	4	4	4	4	70700	76500	172000	109432	.7067	134239	2.2952	21.9799
5707	36 0403151201 1	5	5	5	5	22700	25500	47600	34971	.1506	40485	3.5686	9.5923
5708	36 0403341201 0	5	5	5	5	23500	26000	47600	35492	.1452	40862	3.6068	11.0362
5709	36 0403241201 1	4	4	4	4	35500	40000	70700	48675	.1356	55596	3.1691	9.6413
5710	36 0403241201	4	4	4	4	52900	70700	79500	71949	.0442	74998	11.5211	9.8637
5711	36 0403341201 1	2	2	2	2	85500	100000	100000	92466	.0481	96119	8.7522	8.8496
5712	36 0403241201 0	2	2	2	2	89000	140000	140000	111624	.1391	124858	3.0266	3.0502
512[illegible]	31 10387865410	2	2	2	2	192000	21997700	21997900	8931570	1.3019	23566173	.2728	.2566
5713	36 0403181101 0	7	7	7	7	51000	51000	74000	61055	.0612	65072	7.6383	VERY HIGH
5714	36 0403281201 0	8	8	8	8	58000	68100	144000	80233	.1204	97483	2.9116	8.2676
5715	36 0403241101 1	3	3	3	3	64900	71400	111200	80171	.1240	90695	3.1455	12.7630
5716	36 0403241101 0	3	3	3	3	71600	79200	111200	95673	.1006	94581	3.9436	11.7326
5717	36 0403241101 1	3	3	3	3	14100	28500	29700	22724	.1796	26464	3.2476	1.7205
5718	36 0400241101 0	3	3	3	3	21600	36000	36300	30448	.1291	33971	4.5228	2.3812
5719	36 0403281101 1	4	4	4	4	15500	17000	27500	20506	.1202	23101	3.8430	12.4574
5720	36 0403281101 0	4	4	4	4	23600	25100	34200	29659	.0828	31088	5.7894	18.6742
5721	36 0403221101 1	7	7	7	7	36300	44700	61700	49826	.0703	53533	6.6860	5.1323
5722	36 0440221101 0	7	7	7	7	52500	60900	71200	64176	.0435	67208	11.7145	7.1575
5723	36 0403221101 1	6	6	6	6	35400	44700	61700	48261	.0806	52479	5.6859	5.2553
5724	36 0400221101 0	6	6	6	6	51900	62400	71200	66334	.0301	68425	16.1515	44.9583
5725	36 0403241101 1	3	3	3	3	28000	32400	42700	33836	.0931	37071	4.4096	8.3341
5726	36 0403241101 0	3	3	3	3	35000	36700	44900	39061	.0532	41116	7.3101	63.1537
5727	36 0403241101 1	3	3	3	3	40200	41300	48500	43182	.0441	45110	8.8639	65.0592
5728	36 0400241101 0	3	3	3	3	40200	41300	48500	43182	.0441	45110	8.8639	65.0592
5729	36 0403241101 1	3	3	3	3	238900	261400	264600	248036	.0266	254395	16.6630	116.8459
5730	36 0403241101 0	3	3	3	3	218900	261400	264600	248036	.0266	254395	16.6630	116.8459
5731	36 0403241101 1	3	3	3	3	85700	87700	102000	91877	.0394	95546	9.8519	106.0685
5732	36 0400241101 0	3	3	3	3	86700	87700	102000	91877	.0394	95546	9.8519	106.0685
5733	36 0403241201 1	3	3	3	3	77600	92600	146000	101524	.1421	116638	2.8206	6.7840
5734	36 0403241201 0	3	3	3	3	92600	96700	146000	109364	.1092	121866	3.5616	28.0765

LIST OF CHARACTERISTICS OF DATA GROUPS AND ESTIMATED WEAR PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF DESCRIPTION	NO. OF DATA	NUMBER FAILED	NO. USED FOR LNM	NO. USED FOR WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
5735	36 04022412011	4	4	2	2	72300	116600	259900	106790	.1326	103325	2.0688	2.5492
5736	36 04022412010	4	2	2	2	72300	116600	259900	106790	.1326	103325	2.0688	2.5492
5737	36 04002412011	4	3	3	3	212000	251000	325000	258601	.0935	282803	4.4018	7.2035
5738	36 04002412010	6	6	6	6	137000	211300	443000	275771	.1408	321887	2.8135	15.9330
5739	36 05132311010	2	2	2	2	37000	42000	42000	39421	.0389	40676	10.8169	10.9371
5740	36 05102011010	3	3	3	3	31000	102000	145000	115268	.1372	131982	2.8687	10.6395
5741	36 05132311010	2	2	2	2	95000	140300	140300	115326	.1191	126936	5.5358	5.5751
5742	36 05132811010	9	9	9	9	58000	62000	81300	70909	.0561	75512	7.0671	15.0968
5743	36 04032812011	4	4	4	4	41300	98900	105700	79436	.1922	93599	3.4076	1.5018
5744	36 04032812010	4	4	4	4	71300	91300	110800	92673	.0837	100109	6.3682	6.7180
5820	36 06632421011	4	2	2	2	472000	3391300	3391300	6056744	.8207	10328591	.4104	.5036
5822	46 06632421010	4	2	2	2	3391300	4697900	4697900	6238607	.2208	7492453	1.3730	3.5290
5850	32 00006083011	4	4	4	4	176900	265000	400000	250688	.2217	307119	2.4339	1.6890
5851	32 00001083010	3	3	3	3	127600	370400	502000	287348	.3124	376944	1.7176	1.1414
5852	32 00001083010	4	4	4	4	253200	348400	409000	337732	.0886	365953	6.1690	3.6094
6000	9 06331460810	20	20	20	20	36030	35000	140000	72214	.1963	49131	2.6321	35.3899
6001	9 06331460810	3	3	3	3	31950	33117	35050	33313	.0209	34043	19.4367	31.1821
6002	9 06331160810	3	3	3	3	98667	114900	114833	105094	.0640	110947	9.1248	4.8682
6003	9 06333360810	3	3	3	3	9567	9800	10733	10021	.0264	10284	14.9860	50.9511
6004	9 06333360810	3	3	3	3	15230	17600	17800	16835	.0378	17384	15.3244	8.4103
6005	9 06331460810	3	3	3	3	1033	3500	3967	2430	.3228	3199	1.7811	.9968
6006	9 06331860810	3	3	3	3	4600	5267	5750	5184	.0488	5419	9.7181	8.9956
6007	11 10047865410	3	3	2	2	352900	553700	4385300	509684	.1250	494073	3.0438	2.7009
6008	11 10087865410	2	2	2	2	295200	401100	401100	286890	.2058	338614	2.0457	2.0684
6009	11 10047465410	2	2	2	2	83000	223800	220900	140183	.2790	175506	1.5089	1.5257
6010	11 10097465410	2	2	2	2	45300	124400	124400	75069	.3102	96375	1.3572	1.3723
6011	11 10087865440	2	2	2	2	48400	55400	55400	51782	.0415	53541	10.1500	10.2628
6012	11 10087865410	2	2	2	2	13100	13201	13201	13150	.0024	13183	134.3703	100.4988
6013	11 10047354110	2	2	2	2	77800	842700	842700	256051	.7316	461564	.5795	.5819
6014	11 10087965410	2	2	2	2	91100	105000	105000	97803	.0436	101299	9.6552	9.7525
6015	11 10047965410	2	2	2	2	45100	55000	55000	49805	.0610	52310	6.9088	6.9856
6016	11 10087965410	2	2	2	2	24600	33503	33503	28707	.0948	30986	4.4400	4.4893
6017	11 10087965410	2	2	2	2	9600	12100	12100	10778	.0711	11413	5.9240	5.9898
6018	11 10089465410	2	2	2	2	170000	725500	725000	351070	.4454	502552	.9453	.9558
6019	11 10089365410	2	2	2	2	16400	17000	17000	16697	.0110	16890	28.8186	38.5818
6020	11 10089965410	2	2	2	2	119200	321700	321700	195000	.3075	249792	1.3694	1.3846
6122	11 10089365410	2	2	2	2	725700	1449400	1449400	1025587	.2124	1216961	1.9828	2.0343
6300	10 05108455020	102	102	102	102	233000	258000	560000	392095	.0702	424378	6.0275	9.8590
6301	10 05108455020	101	101	101	101	70000	90000	212000	131863	.0740	143167	6.0038	3.9989
6302	9 06331455810	9	9	9	9	237000	265000	396000	302715	.0695	327089	6.0149	9.4027

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM NO.	DESCRIPTION	SAMPLE SIZE (N)	NUMBER FAILED	SIZE USED FOR MLE LNM	SIZE USED FOR MLE WAL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	459300	565000	565000	514932	.0570	559117	7.3870	7.6699
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	134100	150500	150600	127593	.1018	138497	4.1351	4.1913
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	45500	53500	53500	49338	.0497	51355	8.4649	8.5590
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	251500	309200	309200	278862	.0636	293477	6.6381	6.7113
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	58500	87600	87600	77520	.0751	82352	5.6079	5.6702
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	16400	32300	32300	23186	.1979	27192	2.1278	2.1516
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	653400	1011400	1011400	755134	.1795	872558	2.3461	2.3722
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	96500	121000	121000	108058	.0695	114277	6.0600	6.1273
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	42800	49100	49100	45842	.0422	47426	9.9844	10.0953
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	44300	104400	104800	67906	.2665	94164	1.5798	1.5974
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	10000	11500	11500	10724	.0429	11101	9.8100	9.9193
[illegible]	[illegible]	101	101	101	101	379300	705300	2660000	1362259	.1329	1565727	3.9011	1.5556
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	7913800	9277100	9277100	8566755	.0489	8911053	8.6397	8.7013
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	1833000	7771600	7771600	3835575	.6337	5639132	.9708	.9815
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6114700	7641900	7641900	6835783	.0685	7223299	5.1496	6.2173
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	71300	1303300	2148300	766096	.8063	3996555	.3347	.6185
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2400	51400	6455	.9239	15473	.5871	.4764
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13100	35600	51400	22633	.1859	36105	1.6810	1.8156
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	93300	139300	181000	115247	.1073	127883	3.7991	7.6526
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	250000	273000	273000	261247	.0270	268670	11.7720	15.7514
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	472000	698300	742000	572419	.0962	635171	4.1154	20.8074
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9800	12200	58000	20773	.5657	34009	.9391	.6391
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	31600	47200	95400	52207	.2429	42645	3.4171	3.0315
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	330300	354300	336892	.0641	358146	6.5376	10.5304
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	95000	110300	110300	102225	.0450	106000	9.3522	9.4561
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	237300	278000	355000	245983	.0884	311236	6.7380	7.6234
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	31900	31900	17038	.3852	23235	1.0931	1.1352
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6100	22700	119800	26747	.6185	40091	.7923	.6726
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	76600	448600	63730	.2736	59544	1.3306	1.2336
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	156600	265500	171147	.1897	206870	2.3527	2.5558
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	562000	1008000	688960	.1816	913567	3.4305	1.8493
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	139200	105200	72850	.2686	98899	1.5836	1.7126
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	232400	232400	159417	.1947	198175	[illegible]	2.1873
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	436000	447000	447000	412665	.0639	437287	[illegible]	9.6303
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	55100	55100	48956	.6079	87490	1.0324	1.0638
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	266000	266000	262983	.0070	264602	65.3643	60.7633
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13700	7174	.3606	9688	1.5156	1.1377
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14800	57000	15064	.1170	13473	3.6933	3.0916
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	151800	173000	162025	.0811	168326	11.3670	6.1746
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	177100	187000	175617	.0339	180943	17.4276	9.5971

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	FSC	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE USED FOR MLE LNM	SIZE USED FOR MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(INF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE -BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
6524	12	[illegible]	5	5	4	4	364000	618000	809000	517967	.1306	596683	3.2476	5.6145
6525	12	[illegible]	4	4	4	2	8300	11103	26903	16336	.2522	10497	6.2069	5.2396
6526	12	[illegible]	3	3	3	3	51600	56700	80600	55490	.0281	56866	10.8894	12.9057
6527	12	[illegible]	4	4	3	3	80200	94709	140200	102115	.1246	115295	3.2409	7.3193
6528	12	[illegible]	4	3	4	3	355000	609000	448000	402170	.0509	421177	9.3215	8.5909
6529	12	[illegible]	3	3	3	3	911000	911000	1005000	941313	.0246	949651	16.5053	VERY HIGH
6530	12	[illegible]	3	2	2	2	175000	183000	183000	179466	.0120	181709	26.5520	35.5463
6531	12	[illegible]	3	2	2	2	230000	281000	281000	254224	.0615	267134	6.0459	6.9219
6532	12	[illegible]	4	3	4	3	8000	8209	8500	8231	.0132	8345	30.6053	49.2615
6533	12	[illegible]	4	3	3	3	18500	22000	21709	20024	.0347	20685	12.6792	15.6029
6534	12	[illegible]	3	3	3	3	25500	30900	35700	30728	.0664	32677	6.7728	7.5445
6535	12	[illegible]	3	3	3	3	59600	72309	80600	73951	.0336	76420	11.9575	29.7136
6536	12	[illegible]	3	3	3	3	151000	187300	357000	220688	.1030	264612	2.1394	8.1253
6537	12	[illegible]	6	6	6	4	357000	658000	1264000	675204	.2245	628716	3.5580	1.8819
6538	12	[illegible]	2	2	2	2	14800	19000	19000	16769	.0767	17839	5.4904	5.5496
6539	12	[illegible]	3	2	2	2	28700	33100	33100	30822	.0438	31929	9.6129	9.7191
6540	12	[illegible]	3	2	2	2	54100	81200	81200	74671	.0531	77727	7.9250	8.0133
6541	12	[illegible]	2	2	2	2	203000	250000	250000	225278	.0648	237185	6.5836	6.6567
6542	12	[illegible]	2	2	2	2	11600	12700	12700	12138	.0278	12413	15.1356	15.3018
6543	12	[illegible]	2	2	2	2	30400	36903	36900	33767	.0545	35282	7.7262	7.8121
6544	12	[illegible]	2	2	2	2	87800	93000	93000	90363	.0177	92033	18.0091	24.0935
6545	12	[illegible]	2	2	2	2	13500	14600	14600	14039	.0241	14396	13.2260	17.6977
6546	12	[illegible]	2	2	2	2	21500	37000	37000	28205	.1667	32257	2.5256	2.5537
6547	12	[illegible]	2	2	2	2	75500	115000	115000	93180	.1292	103400	3.2582	3.2944
6548	12	[illegible]	3	2	2	2	120000	161800	161800	139361	.0918	150031	4.5875	4.6385
6549	12	[illegible]	3	2	2	2	13000	14500	14500	13730	.0335	14105	12.5596	12.6951
6550	12	[illegible]		2	2	2	25900	28103	28100	26978	.0290	27687	12.7079	17.0342
6551	12	[illegible]	2	2	2	2	60900	70000	70000	53507	.1650	61112	2.5515	2.5790
6552	12	[illegible]	2	2	2	2	241000	241000	241000	250801	.0245	257248	12.9952	17.3888
6553	12	[illegible]	3	3	3	3	10800	11203	13800	11862	.0575	12557	6.8037	33.6472
6554	12	[illegible]	3	3	3	3	17200	20200	25800	20773	.0887	22613	4.7260	7.5659
6555	12	[illegible]	3	3	3	3	32600	37600	43600	37590	.0645	39918	6.8066	8.1722
6556	12	[illegible]	3	3	3	3	51400	56200	87600	63993	.1212	72086	3.2751	9.7901
6557	12	[illegible]	3	3	3	2	130800	165600	371600	190837	.2030	155909	5.7559	5.1366
6558	12	[illegible]	3	3	3	3	7700	8300	8400	8127	.0205	8271	27.5499	16.2133
6559	12	[illegible]	4	4	4	4	14500	16200	19509	16555	.0532	17491	7.5333	10.3798
6560	12	[illegible]	3	2	2	2	21300	31109	31100	26745	.0927	28817	4.5462	4.5367
6561	12	[illegible]	3	3	3	3	94300	94200	135900	107964	.0870	117709	4.6767	30.0159
6562	12	[illegible]	2	2	2	2	8500	8501	8501	8500	.0000	8501	6900.0617	VERY HIGH
6563	12	[illegible]	3	3	3	3	11200	16493	17700	15178	.0926	16434	6.0195	3.6563

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS • UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE USED FOR MLE LNM	SIZE USED FOR MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
6564	12	12827411010	3	3	3	3	36700	40500	62400	45246	.1226	51094	3.2095	12.3460
6565	12	12836411010	2	2	2	2	10300	12700	12700	11437	.0643	12045	6.5458	5.6185
6566	12	12834411010	2	2	2	2	29500	45200	45200	36516	.1310	40580	3.2131	3.2608
6567	12	12834811010	2	2	2	2	57200	212500	212500	110250	.4030	152526	1.0447	1.0563
6568	12	12834811010	2	2	2	2	335000	1273000	1273000	653035	.4100	908514	1.0270	1.0384
6569	12	12836411010	2	2	2	2	47000	93700	93700	66362	.2119	78710	1.9872	2.0393
6570	12	12836411010	2	2	2	2	378400	378401	378401	378400	.0000	378405	26761.8656	VERY HIGH
6571	12	12827411010	2	2	2	2	10400	13900	13900	12023	.0891	12918	4.7264	4.7798
6572	12	12827411010	2	2	2	2	29200	54200	54200	39782	.1900	46358	2.2167	2.2613
6573	12	12827811010	2	2	2	2	73300	113700	113700	91292	.1348	101762	3.1231	3.1578
6574	12	12827811010	2	2	2	2	222000	652000	652000	380452	.3309	496618	1.2726	1.2867
6575	12	12827811010	2	2	2	2	12700	13600	13600	13142	.0210	13432	15.1306	20.2474
6576	12	12827411010	2	2	2	2	19200	26100	26100	22386	.0963	26152	4.4656	4.5152
6577	12	12827811010	2	2	2	2	57400	109600	109600	79305	.1981	93116	2.1255	2.1491
6582	71	08050833010	4	4	4	4	591210	633900	721990	646276	.0360	670800	11.1264	16.5950
6583	71	09050833010	3	3	3	3	14271	22924	24750	20080	.1295	22436	4.3532	2.9669
6660	12	12834818010	3	3	3	3	2021000	3603000	4075000	3036623	.1581	3406832	3.3004	2.3304
6661	12	12834418010	4	4	4	4	1610000	1796000	4000000	2185369	.1787	2651760	2.0526	10.5295
6662	12	12833818010	2	2	2	2	1200000	1209000	1209000	1204492	.0023	1207372	138.1009	185.5315
6663	12	12833818010	2	2	2	2	1924000	3361000	3361000	2542944	.1713	7919137	2.4578	2.4651
6664	12	12827816010	3	3	2	2	570000	1330000	4500000	1138111	.2351	1073532	1.6182	1.4356
6665	12	12827818010	4	2	2	2	954000	137 000	1321000	6505179	.8404	14774362	.3305	3.6525
6666	12	12827818010	2	2	2	2	1493000	2093000	2093000	1882405	.0651	1983785	6.4643	4.5362
6667	12	12833811010	2	2	2	2	1659000	3830000	3800000	2510060	.2547	3081556	1.6531	1.6715
6669	12	12836811010	2	2	2	2	1155000	1462000	1462000	1305079	.0697	1380473	6.0377	6.1046
6670	12	12827411010	2	2	2	2	3475000	5471000	5471000	4328761	.1438	4860387	2.9274	2.9599
6700	71	03050433070	5	5	5	5	434	539	1227	738	.1921	896	2.3086	5.1494
6701	71	04050433070	5	5	5	5	165	207	396	232	.0982	255	5.0261	5.3646
6702	71	08050433070	3	3	3	3	194	215	230	212	.0372	220	12.7076	11.8350
6703	71	09050833080	3	3	3	3	219	264	274	251	.0522	263	10.6504	6.5091
6900	9	36031806410	3	3	3	3	92000	108000	135000	106135	.1085	117201	4.2123	9.4106
6901	9	40032506410	3	3	3	3	9200	10600	12630	10711	.0684	11426	5.2807	8.5973
6902	9	40032806410	4	4	4	4	123000	126000	165000	133417	.0625	142770	5.8431	23.5053
6903	9	40032806410	2	2	2	2	88200	136000	136000	109523	.1330	121904	3.1661	3.2312
6904	9	40032806410	2	2	2	2	202000	236000	236000	218339	.0478	226903	8.8135	8.9114
6905	9	40032406410	3	3	3	3	467000	491000	513000	488218	.0228	499915	17.7946	19.9805
6906	9	40032406410	2	2	2	2	547000	643000	643000	593061	.0497	617250	8.4793	8.5735
6907	9	83232460810	2	2	2	2	191000	462000	462000	289175	.2878	364596	1.4631	1.4794
6908	9	03031360410	5	4	3	3	163000	192000	712000	197312	.0835	206094	8.5106	3.7866
6909	9	03031360410	3	3	3	3	93000	95000	108000	98449	.0351	101936	11.1172	57.1604

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	FFF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE USED FOR MLE LNM	SIZE USED FOR MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(INF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TBB-ALFA)
6910	0	03031360410	3	3	3	3	78000	102000	120000	98467	.0945	107241	5.0766	4.5363
7000	50	30022430410	4	4	2	2	215330	443000	1278000	455232	.2251	367125	1.9169	1.6060
7001	53	30022360410	5	5	5	5	97000	297000	609000	316173	.3131	421054	1.0369	.9970
7002	50	30022960410	3	3	3	3	96000	177000	272000	165408	.2321	204320	2.0264	1.9221
7003	50	30022960410	5	4	4	4	76000	172000	377000	190256	.2404	246639	1.6998	1.3228
7004	51	30022460410	5	5	5	5	59000	67000	82000	69930	.0563	74073	8.0131	6.7749
7005	51	30022460410	7	7	7	7	55000	55000	76000	62083	.0489	65585	7.0608	VERY HIGH
7006	51	30022360410	4	4	4	4	40000	46000	95000	59354	.1726	70632	2.5230	8.2335
7007	51	30022360410	8	4	8	8	52000	54000	176000	77289	.1544	91911	2.0660	28.3059
7008	52	30022960410	5	5	4	5	35000	36000	61000	45018	.1309	50012	4.2731	13.5669
7009	55	20020860410		2	2	2	68000	104000	104000	84095	.1305	93413	3.2269	3.2628
7010	55	20020860110	2	2	2	2	85000	104000	104000	94021	.0620	98831	6.7962	6.8717
7011	55	20020860110	2	2	2	2	282000	543000	543000	391313	.2012	460151	2.0926	2.1190
7012	55	20020860110	2	2	2	2	85000	109000	109000	96819	.0728	102664	5.7051	5.8495
7013	55	20020860110	2	2	2	2	86000	109000	109000	96819	.0728	102664	5.7051	5.8493
7014	55	30020860410	2	2	2	2	161000	230000	230000	192432	.1095	210178	3.8440	3.8867
7015	55	30020860110	2	2	2	2	226000	476000	476000	327988	.2280	394336	1.8486	1.8611
7016	55	30020860110	2	2	2	2	131000	280000	280000	191520	.2333	231102	1.8090	1.8291
7017	55	30020860010	2	2	2	2	345000	1038000	1038000	598423	.3383	785820	1.2447	1.2505
7018	56	20020860410	5	5	5	5	22000	22300	25000	22966	.0263	23627	15.4071	VERY HIGH
7019	56	20020860410	5	5	5	5	37000	39000	54000	44487	.0737	47856	6.3186	41.8369
7020	56	20020860410	2	2	2	2	68000	104000	104000	84095	.1305	93413	3.2269	3.2628
7021	56	20020860410	5	5	4	4	171000	205000	1247000	318851	.2175	379101	2.1426	6.1526
7022	56	20020860110	2	2	2	2	85000	104000	104000	94021	.0620	98831	6.7962	6.8717
7023	56	20020860110	2	2	2	2	282000	543000	543000	391313	.2012	460151	2.0926	2.1190
7000	56	20020360110	2	2	2	2	176000	244000	244000	175340	.2030	206475	2.0766	2.0976
7001	56	20020860110	2	2	2	2	271000	364000	364000	305326	.0733	323000	5.7401	5.8120
7002	56	30020860410	3	3	3	3	36000	51000	53000	45996	.0925	49770	6.1996	3.4923
7003	56	30020860410	4	3	3	3	151000	230000	287000	246289	.1281	274164	3.3628	3.2265
7004	55	30020360110	2	2	2	2	52000	70000	70000	60332	.0913	64935	4.6125	4.6637
7005	56	30020360110	3	2	2	2	226000	476000	476000	399151	.4097	899482	.6563	1.6339
7006	56	30020360110	2	2	2	2	51000	80000	80000	69057	.0933	74782	5.0566	5.1126
7007	56	30020860110	2	2	2	2	345000	1038000	1038000	598423	.3383	785820	1.2447	1.2505
7069	54	20020855110	2	2	2	2	19000	22000	22000	20445	.0450	21200	9.3522	9.4561
7070	54	20020855110	2	2	2	2	32000	126000	126000	63498	.4789	89120	1.0006	1.0119
7071	54	20020855110	2	2	2	2	57000	69000	69000	62714	.0587	65740	7.1763	7.2560
7072	54	20020855110	2	2	2	2	75000	219000	219000	128160	.3291	167853	1.2799	1.2937
7073	54	30020355410	2	2	2	2	24000	45000	45000	32863	.1931	38391	2.1811	2.2053
7074	54	30020355410	2	2	2	2	130000	191000	191000	157575	.1182	173366	3.5636	3.6032
7100	41	16020821410	3	3	3	3	13000	14600	17000	14572	.0602	15454	6.6676	16.6136

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE USED FOR LN4	SIZE USED FOR WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
7101	[illegible]	[illegible]	3	3	3	28000	34000	34000	31869	.0487	33213	12.0029	6.2650
[illegible]	[illegible]	[illegible]	3	3	3	63000	65300	67003	64970	.0193	65880	21.0371	26.7561
[illegible]	[illegible]	[illegible]	3	2	2	54000	69300	69000	61041	.0759	64856	5.5954	5.6955
[illegible]	[illegible]	[illegible]	2	2	2	15000	22000	22000	18762	.0978	20299	6.3056	6.3532
[illegible]	[illegible]	[illegible]	3	4	3	284000	360000	345000	321765	.0471	334897	12.2869	6.7500
[illegible]	[illegible]	[illegible]	3	2	2	39000	39001	39001	39000	.0000	39001	17816.9589	VERY HIGH
[illegible]	[illegible]	[illegible]	3	2	2	264100	394100	1567303	360767	.1329	369028	2.0612	2.5305
[illegible]	[illegible]	[illegible]	2	2	2	30000	62000	67000	43520	.2229	51610	1.6087	1.9297
[illegible]	[illegible]	[illegible]	3	3	3	26000	25000	36000	27850	.0970	30665	6.0110	29.7975
[illegible]	[illegible]	[illegible]	2	2	2	463000	449300	649000	611659	.0731	668765	5.7576	5.0215
[illegible]	[illegible]	[illegible]	3	3	3	23000	36000	39000	31466	.1236	35606	4.5326	2.7159
[illegible]	[illegible]	[illegible]	2	2	2	217300	573000	573300	352620	.2982	448335	1.6120	1.6277
[illegible]	[illegible]	[illegible]	[illegible]	4	4	20000	25300	27000	23811	.0677	25265	7.7365	5.6512
7114	[illegible]	[illegible]	4	3	2	373000	472000	782300	466165	.2090	388067	4.1388	3.6719
[illegible]	[illegible]	[illegible]	4	3	3	38000	51300	52000	46536	.0763	49653	7.4016	4.1362
[illegible]	[illegible]	[illegible]	3	[illegible]	3	386300	450000	625300	604315	.2162	490449	2.2056	1.8720
7117	[illegible]	[illegible]	3	3	3	41300	46300	51300	45818	.0476	47875	9.6013	12.5713
[illegible]	[illegible]	[illegible]	3	2	2	417300	768300	768300	2136028	.8638	5639103	.2891	2.0917
[illegible]	[illegible]	[illegible]	3	3	3	26000	27300	27300	25960	.0294	26613	19.7058	10.3274
[illegible]	[illegible]	[illegible]	2	2	2	333300	392000	352300	360755	.0510	375886	4.2531	8.3468
7121	[illegible]	[illegible]	3	3	3	31000	42000	40000	34108	.0601	36217	6.6609	38.3132
[illegible]	[illegible]	[illegible]	3	3	2	233100	337000	792303	303245	.1365	293159	2.7871	2.6727
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	5300	5300	6662	.0560	4767	10.6636	5.6512
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	45300	53300	47180	.0441	49278	8.8316	56.1275
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	51000	47309	.0573	46107	5.2608	3.9213
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	469792	.0156	493715	25.0431	25.3316
7127	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26464	.1927	41923	2.1179	4.2203
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	229790	.0276	228736	13.0863	12.3198
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14655	.0173	14926	23.6695	17.6907
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	346427	.2276	475066	2.6551	1.6750
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	27473	.0620	29175	6.7113	10.3276
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	659501	.0506	655506	9.4565	7.9601
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	35312	.0187	36041	21.7750	61.9627
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	366803	.0626	360933	6.3113	8.1303
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	40000	21852	.1716	24653	3.7133	6.6301
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	316562	.1775	[illegible]	7.1676	1.0351
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14190	.1055	17071	6.5102	3.7102
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	27166	.0256	28768	16.3108	30.6907
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	27868	.0656	26776	9.3621	16.3766
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	65331	.3056	[illegible]	70.6095	VERY HIGH

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

[illegible]	[illegible]	[illegible]	NUMBER FAILED	[illegible]	USED	FIRST FAILURE	SECOND FAILURE	LAST FAILURE	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOS-ALFA)
7161	[illegible]	[illegible]	[illegible]	[illegible]	3	579000	549100	771000	611063	.0876	644439	4.6289	66.1700
7162	[illegible]	[illegible]	[illegible]	[illegible]	3	61300	66300	75900	56964	.1313	62220	3.2856	6.6166
7163	[illegible]	4	4	4	4	45300	76000	98300	73903	.1507	86676	3.8839	2.1957
7164	[illegible]	[illegible]	[illegible]		2	41000	16300	36300	34607	.0459	36665	9.1690	9.2708
7165	[illegible]	4	4	4	4	31000	46000	63000	37679	.0661	60098	7.0506	7.6355
7166	[illegible]	4	4	4	4	22000	23000	35000	26537	.0922	29196	6.3099	25.8871
7167	[illegible]	[illegible]	2	2	2	11300	16000	36000	19900	.3641	26681	1.1566	1.1693
7168	[illegible]	[illegible]	4	[illegible]	4	94000	98000	352000	158767	.2364	151366	3.0048	26.7736
7169	[illegible]	4	4	4	4	129000	190000	296000	205507	.1526	237122	3.2616	2.6850
7170	[illegible]	[illegible]	4	4	4	68200	110000	165900	96656	.2096	116188	2.0269	1.3876
7151	[illegible]	[illegible]	[illegible]	[illegible]	2	765000	791000	791300	767696	.0186	782661	17.2096	23.1382
7152	[illegible]	[illegible]	[illegible]	[illegible]	3	277000	333007	675090	385145	.1860	642589	2.1268	6.9678
726[illegible]	[illegible]	[illegible]	3	[illegible]	3	1091000	1702000	2728309	1717619	.1990	2049295	2.2028	2.7353
7261	[illegible]	[illegible]	[illegible]	4	3	1306000	1722000	1775000	1586323	.0734	1688753	7.0165	4.3993
726[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	1561000	3532000	3552000	4816046	.4822	7791696	.5555	1.4484
726[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	545000	1136000	3925300	1048626	.1984	998157	1.9177	1.7312
76[illegible]	[illegible]	[illegible]	[illegible]	2	2	31500	48300	48300	39006	.1313	43345	3.2076	3.2632
76[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	853370	915230	936850	900056	.0220	920776	10.5133	16.5687
76[illegible]	[illegible]	[illegible]	[illegible]	3	3	461100	567300	568300	521651	.0650	552140	8.1001	5.6300
76[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	36600	53000	69200	50217	.1383	57153	3.1780	3.8093
7604	[illegible]	[illegible]	4	[illegible]	4	73300	46100	106500	90919	.0789	98078	6.3776	8.1296
7605	[illegible]	3	3	[illegible]	2	33600	59800	191500	55985	.1158	59811	3.2860	2.9153
7606	[illegible]	[illegible]	[illegible]	2	2	15530	28490	28490	21297	.1805	24549	2.3331	2.3591
7607	[illegible]	[illegible]	3	[illegible]	2	109930	109860	109860	106838	.0171	108753	18.5709	26.5530
7608	[illegible]	[illegible]	[illegible]	[illegible]	2	1666000	1663100	1666100	1653033	.0030	1657562	106.6513	162.8609
7609	[illegible]	[illegible]	[illegible]	[illegible]	3	1559000	1699100	1731600	1661651	.0263	1703812	16.7368	14.1392
7610	[illegible]	[illegible]	[illegible]	[illegible]	3	513000	586700	718603	580497	.1265	772696	3.6985	6.1711
7611	[illegible]	41	41	41	41	84600	108560	769552	151228	.0870	166594	5.1635	4.9782
7612	[illegible]	[illegible]	[illegible]	[illegible]	3	2901	4233	4286	3749	.0965	4068	6.0506	3.2372
7613	[illegible]	[illegible]	2	[illegible]	2	1483	3633	3630	2565	.1892	2950	2.2985	2.3240
7721	[illegible]	[illegible]	[illegible]	[illegible]	2	2110	2160	2160	2135	.0872	2151	46.1920	59.1321
7722	[illegible]	2	[illegible]	[illegible]	2	1733	1954	1898	1816	.0271	1856	15.5686	15.7615
7723	[illegible]	[illegible]	[illegible]	[illegible]	2	596	1272	1272	941	.1852	1092	2.2737	2.2993
7751	[illegible]	[illegible]	[illegible]	[illegible]	2	1313200	1566400	4600000	1694271	.0491	1668622	5.5006	4.8803
775[illegible]	[illegible]	[illegible]	4	4	4	373600	1769600	2052900	1756391	.3525	1688373	1.0570	.7656
7763	[illegible]	[illegible]	[illegible]	[illegible]	2	147900	4160000	4160000	780115	1.0253	1781154	.6107	.6153
7764	[illegible]	[illegible]	[illegible]	[illegible]	2	552000	4953300	4950300	1667903	.6681	2856671	.6302	.6372
74[illegible]1	[illegible]	[illegible]	[illegible]	[illegible]	2	1160	1239	1239	1196	.0180	1217	17.4788	23.6593
74[illegible]	[illegible]	[illegible]	[illegible]	2	2	796	1012	1012	898	.0737	952	5.7107	5.7742
74[illegible]4	[illegible]	[illegible]	[illegible]	[illegible]	2	725	1386	1386	1002	.1986	1175	2.1205	2.1641

LIST OF SALIENT FEATURES OF DATA GROUPS
USED TO ESTIMATE SHAPE PARAMETERS

UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL
POPULATION PARAMETERS FOR DATA GROUPS

ITEM	REF DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR MLE LNM	USED FOR MLE WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE -BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TOG-ALFA)
8000	31 00053081011	3	3	3	3	441300	971400	1460000	880486	.2438	1096753	1.9810	1.7321
8001	31 00053181010	3	3	3	3	130000	195100	216800	176503	.1173	195377	6.6234	2.9062
8002	35 05150712010	7	7	7	7	36000	40000	46000	42018	.0566	43534	15.0614	10.2415
8003	36 05150821010	4	4	4	4	41000	47000	72000	51576	.1042	57571	3.7024	8.4296
8004	36 05150821010	3	3	3	3	22000	25000	36000	27053	.1110	30161	3.5982	9.5155
8005	35 05150411010	4	4	4	4	53000	57000	113000	73177	.1536	85570	2.7680	15.8155
8006	35 05151811010	4	4	4	4	25000	26000	51000	32093	.1421	37349	2.0665	29.3398
8121	31 00053381010	3	3	3	3	835900	1408100	2156000	1395877	.1907	1666718	2.3396	2.6901
8122	35 05150621010	3	2	2	2	1451000	2456000	2456000	2858500	.2805	3771466	.9619	2.3419
8123	35 05150811010	2	2	2	2	2049000	2556000	2556000	2309828	.0617	2427541	6.8220	6.8878
8150	70 00050087020	2	2	2	2	315000	323000	323000	318875	.0077	321534	41.2726	55.2756
8151	70 00050087020	2	2	2	2	54000	65301	65000	59245	.0569	62025	7.3950	7.4772
8300	31 00058087011	3	3	3	3	136200	142700	247700	168853	.1445	196931	2.6873	26.8816
8301	31 00058087011	3	3	3	3	396800	424800	450000	423908	.0276	435403	16.8507	17.8399
8302	31 00059081011	3	3	3	3	13437	26318	27585	21367	.1748	24788	3.3175	1.8395
8303	31 00058083011	3	3	3	3	73500	273300	797000	251592	.5174	405182	.8829	.9262
8304	31 00059083011	3	3	3	3	11200	13300	20100	14413	.1305	16370	3.0890	7.0702
8305	31 00059087011	2	2	2	2	39700	39800	39800	39750	.0008	39782	486.7236	551.0517
8306	31 00059087011	2	2	2	2	335600	793600	793600	516074	.2643	630494	1.5930	1.6107
8307	32 00058087011	2	2	2	2	22900	61800	61800	37619	.3049	48089	1.3011	1.3966
8308	32 00059081011	2	2	2	2	31600	35100	35100	33304	.0323	34181	13.0923	13.1975
8309	32 00059081011	5	5	5	5	19600	22303	29400	23732	.0726	25597	5.9995	8.8711
8310	32 00058087011	2	2	2	2	13000	15770	15770	14318	.0593	15019	7.0901	7.1769
8311	32 00058083011	2	2	2	2	13000	13940	13840	13413	.0192	13684	16.5445	22.1465
8312	31 00058087010	2	2	2	2	587200	967003	957003	753540	.1532	852409	2.7405	2.7791
8314	31 00058083010	3	3	3	3	25100	25600	48100	31900	.1616	34762	2.3970	102.3787
8315	31 00059087010	2	2	2	2	56300	56100	56100	55193	.0100	55769	31.7499	42.5393
8316	31 00059187010	3	3	3	3	379600	424800	865400	518692	.1941	628730	2.0111	18.8126
8317	32 00059381010	2	2	2	2	47600	49500	49500	49541	.0120	49150	26.4586	35.4189
8318	32 00058087010	2	2	2	2	8250	12410	12410	10106	.1261	11187	3.3382	3.3795
8319	32 00058083010	2	2	2	2	13000	13930	13930	13457	.0212	13756	16.9932	20.0695
8320	33 00020083010	3	3	3	3	155000	172300	193009	176630	.0342	182670	11.6030	34.[illegible]02
8321	33 00020083010	3	3	3	3	256000	456000	582000	406981	.1851	479286	2.7533	2.0787
8322	33 00020083010	6	6	6	6	115000	130000	212700	163258	.1034	180732	5.0918	8.9226
8323	34 00059187011	3	3	3	3	23900	29700	35800	29480	.0870	31686	5.1528	5.9986
8324	34 00059187011	6	6	6	6	31800	32600	50700	40220	.0884	44102	5.2481	44.8284
8325	34 00059087010	4	4	4	4	35500	38100	56100	45177	.1040	50039	4.6104	16.2985
8326	35 16050083010	4	4	4	2	15000	27000	59000	34869	.7756	23654	2.6208	2.1902
8327	35 16050083010	4	4	4	4	19000	20000	23000	20498	.0353	21463	11.6081	22.4343
8328	35 16050083010	4	4	4	4	9000	15000	18900	14257	.1372	16066	4.5060	2.2527

LIST OF SALIENT FEATURES OF DATA GROUPS USED TO ESTIMATE SHAPE PARAMETERS • UNBIASED POINT ESTIMATES OF LOG-NORMAL AND WEIBULL POPULATION PARAMETERS FOR DATA GROUPS

ITEM	FSC	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	SIZE FOR MLE LN*	USED WBL	FIRST FAILURE (F(1))	SECOND FAILURE (F(2))	LAST FAILURE (F(NF))	LOG-NORMAL SCALE (MLE-MU)	LOG-NORMAL SHAPE (MLE-SIGMA)	WEIBULL SCALE (MLE-BETA)	WEIBULL SHAPE (MLE-ALFA)	WEIBULL SHAPE (TCS-ALFA)
8329	35	16050083010	4	4	4	4	23000	27000	39000	30343	.1065	32606	4.5266	7.1767
8330	35	16050083010	5	5	5	5	11000	14000	29000	15647	.1543	18699	2.2532	6.5264
8331	35	16050083010	5	5	5	5	19000	25000	38000	27492	.1109	30711	4.1536	4.0655
8332	35	16050083010	4	4	4	4	10000	14000	23000	16314	.1720	19220	2.9544	3.4200
8333	35	16050083010	4	4	4	3	30000	33000	83000	40883	.2063	53097	18.6836	12.8735
8334	35	16050083010	3	3	3	3	148000	304000	441000	287406	.2114	341980	2.2569	2.0513
8335	35	16050083010	3	3	3	3	223000	235000	243000	229210	.0174	233385	23.3398	136.2356
8336	35	16050083010	4	4	4	4	10000	11000	13000	11445	.0491	12010	9.3388	12.0735
8337	35	16050083010	4	4	4	4	37000	44000	45000	42611	.0411	44113	16.5417	6.6612
8338	35	16050083010	3	3	3	3	83000	108000	138000	107348	.1104	118943	6.0478	4.6203
8339	35	16050083010	4	4	4	4	188000	243000	355000	261154	.1129	291679	3.9766	3.4277
8340	35	16050083010	4	4	4	4	106000	113000	126000	113221	.0351	117398	11.4915	28.5159
8341	35	16050083010	4	4	4	4	309000	362000	409000	361188	.0506	378067	9.6786	7.2692
8342	35	16050083010	2	2	2	2	27000	31000	31000	28931	.0424	29937	9.9244	10.0347
8343	35	16050083010	3	3	3	3	81000	84000	98000	84285	.0181	85876	22.5199	33.4472
8344	35	16050083010	4	4	4	4	229000	250000	269000	251551	.0302	258692	17.7476	13.1154
8345	35	16050083010	2	2	2	2	33000	56000	56000	42988	.1624	48995	2.5926	2.6216
8346	35	16050083010	2	2	2	2	103000	198000	198000	142808	.2007	167861	2.0979	2.1212
8347	35	16050083010	2	2	2	2	58000	114000	114000	88045	.1507	100047	2.6535	2.6838
8348	35	16050083010	4	4	4	4	18000	28000	35000	26510	.1211	29631	4.2989	2.6344
8349	35	16050083010	4	4	4	4	59000	105000	108000	91768	.1280	102113	5.6788	1.9963
8350	35	16050083010	4	4	3	3	97000	141000	648000	142391	.1250	143235	4.1221	2.6981
8351	35	16050083010	4	4	4	4	39000	41000	60000	47928	.0926	52541	4.9888	23.0298
8352	35	16050083010	4	4	4	4	141000	141000	315000	204083	.1868	245602	2.5819	VERY HIGH
8353	35	16050083010	3	3	3	3	240000	801000	949000	589840	.3384	786056	1.7223	.9195
8354	35	16050083010	4	4	4	4	189000	192000	242000	209890	.0513	221117	8.5635	73.8897
8355	38	16020073010	5	5	5	5	22000	28000	50000	33177	.1500	38758	2.9700	4.6264
8357	38	16020074010	5	5	4	5	51000	64000	95000	74718	.0898	82045	4.9149	23.2397
8421	31	00058983011	3	3	2	2	136	234	662	212	.1505	284	2.5265	2.2415
8422	32	00058187011	3	3	3	3	3200	5120	6010	4618	.1473	5229	3.6872	2.5881
8423	32	00058387011	3	3	3	3	1290	1600	2970	1830	.1800	2200	2.1233	5.6482
8424	31	00058033010	3	3	3	3	670	680	1010	772	.1011	854	3.0329	82.1352
8425	32	00058083010	2	2	2	2	8090	9900	9900	8949	.0620	9408	6.7906	6.8660
8426	32	00058387010	2	2	2	2	2510	3870	3870	3117	.1330	3469	3.1666	3.2818
8427	35	16050083010	2	2	2	2	6000	7000	7000	6481	.0473	6735	8.8963	8.9931
8461	33	00020383010	3	3	3	3	699000	4436000	6330000	2697475	.5138	4194257	1.0047	.6583
8462	34	00059097011	3	3	3	3	753000	1178000	1339500	1062631	.1291	1108583	4.1462	2.7795
8463	34	00059008709	2	2	2	2	826000	1370000	1370000	1063776	.1554	1209584	2.7098	2.7989
8621	31	00059083011	5	5	5	5	660	790	900	798	.0585	835	10.6329	6.2396
71	1	04010960010	5	5	5	5	10800	12600	17280	13414	.0752	14526	5.3908	7.2378

APPENDIX III

LISTED VALUES OF FATIGUE-LIFE OBSERVATIONS FOR ALL COLLECTED SAMPLES

This appendix retabulates the item and description numbers given in Appendix II to provide a cross-referencing capability between the two tabulations. In addition, this tabulation itemizes all the individual observations from the collected data and categorizes them as either a failed or a suspended item.

LISTED NUMBERS OF CYCLES TO FAILURE AND CYCLES TO SUSPENSION OF TESTING WITHOUT FAILURE FOR ALL GROUPS IN THE DATA COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
1	1	04010860010	5	5	2144	6200	7509	7573	11860	NO SUSPENDED ITEMS
2	1	04010860010	5	5	3300	3954	3963	6315	6377	NO SUSPENDED ITEMS
3	1	04010860010	5	5	2765	3130	4641	6264	8091	NO SUSPENDED ITEMS
4	1	04010860010	5	5	3272	3904	4269	4998	5200	NO SUSPENDED ITEMS
5	1	04010860010	5	5	1290	2445	3372	3600	5179	NO SUSPENDED ITEMS
6	1	04010860010	5	5	4331	4500	4924	5400	6300	NO SUSPENDED ITEMS
7	1	04010860010	5	5	10800	37800	39600	43200	108000	NO SUSPENDED ITEMS
8	1	04010860010	5	5	10800	12600	23400	27000	41400	NO SUSPENDED ITEMS
9	1	04010860010	5	5	9000	10800	10900	16200	19800	NO SUSPENDED ITEMS
10	1	04010860010	5	5	7995	8722	10655	10707	11295	NO SUSPENDED ITEMS
11	1	04010860010	5	5	12600	12600	14400	16200	16200	NO SUSPENDED ITEMS
12	1	04010860010	5	5	3600	5400	6650	6900	7050	NO SUSPENDED ITEMS
13	1	04010860010	5	5	12600	12600	14400	17463	25200	NO SUSPENDED ITEMS
14	1	04010860010	5	5	7200	36000	75600	270000	295560	NO SUSPENDED ITEMS
15	1	04010860010	5	5	27000	27540	49680	52800	55800	NO SUSPENDED ITEMS
16	1	04010860010	5	5	23400	32400	34200	43600	84600	NO SUSPENDED ITEMS
17	1	04010860010	5	5	13960	14400	16920	54600	79740	NO SUSPENDED ITEMS
18	1	04010860010	5	5	27600	63000	82800	86400	93600	NO SUSPENDED ITEMS
19	1	04010860010	5	5	196560	198000	199540	201600	239400	NO SUSPENDED ITEMS
20	1	04010860010	5	5	176400	180000	232200	246600	460800	NO SUSPENDED ITEMS
22	1	04010860010	5	5	3600	4283	4488	6480	7200	NO SUSPENDED ITEMS
23	1	04010860010	5	5	1863	2500	2900	5944	8150	NO SUSPENDED ITEMS
24	1	04010860010	5	5	1471	2325	2600	3053	3170	NO SUSPENDED ITEMS
25	1	04010860010	5	5	88200	98200	179600	691300	1296000	NO SUSPENDED ITEMS
26	1	04010860010	2	2	12015	14856				NO SUSPENDED ITEMS
27	1	04010860010	5	5	1200	1800	2310	3150	4633	NO SUSPENDED ITEMS
28	1	04010860010	5	5	26280	28800	29700	36100	378000	NO SUSPENDED ITEMS
29	1	04010860010	5	5	9000	9600	10500	12600	27000	NO SUSPENDED ITEMS
30	1	04010860010	5	5	6300	6450	7200	7950	15040	NO SUSPENDED ITEMS
31	1	04010860010	5	5	25200	36000	73440	82620	576000	NO SUSPENDED ITEMS
32	1	0401086001	5	5	6150	6300	7872	8100	8620	NO SUSPENDED ITEMS
33	1	04010860010	5	5	14400	16740	19800	32400	34200	NO SUSPENDED ITEMS
34	1	04010860010	5	5	61200	63000	64403	92800	872000	NO SUSPENDED ITEMS
35	1	04010860010	5	5	99000	174600	370400	408600	2196000	NO SUSPENDED ITEMS
36	1	04010860010	5	5	2880	6176	6343	6999	7258	NO SUSPENDED ITEMS
37	1	04010860010	5	5	51400	101500	102600	111900	441600	NO SUSPENDED ITEMS
38	1	04010860010	5	5	1500	2450	3603	4169	4950	NO SUSPENDED ITEMS
39	1	04010860010	5	5	2527	28800	30403	57603	64800	NO SUSPENDED ITEMS
40	1	04010860010	5	5	916	3600	4438	7203	22544	NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
41	1	04010860010	6	6	25200	37600	41600	43600	43800	NO SUSPENDED ITEMS
					45070					
42	1	04010860010	5	5	3342	3465	3537	4075	4330	NO SUSPENDED ITEMS
43	1	04010860010	6	6	9900	10600	11900	13700	14600	NO SUSPENDED ITEMS
					14700					
44	3	30012865830	10	10	70000	76000	80000	81000	86000	NO SUSPENDED ITEMS
					108000	142000	144000	282000	3318000	
45	3	30012865830	10	10	82000	94000	131000	131000	207000	NO SUSPENDED ITEMS
					229000	295000	349000	721000	11600000	
46	3	30012865830	10	10	7100	7400	7800	8000	8400	NO SUSPENDED ITEMS
					8700	9000	9600	9600	9600	
47	3	30012865830	10	10	15400	15900	16000	16100	16300	NO SUSPENDED ITEMS
					16400	17100	17600	17700	19200	
48	3	30012865830	10	10	40000	44000	46000	51000	52000	NO SUSPENDED ITEMS
					57000	59000	63000	67000	269000	
49	3	30012865830	10	10	121000	171000	205000	446000	480000	NO SUSPENDED ITEMS
					592000	662000	877000	1916000	18499000	
50	3	30012865830	10	10	61000	192000	210000	303000	435000	NO SUSPENDED ITEMS
					423000	643000	722000	739000	763000	
51	3	30012865830	10	10	17000	17000	20000	28000	29000	NO SUSPENDED ITEMS
					33000	36000	36000	36000	41000	
52	3	30012865830	10	10	29000	31000	36000	44000	47000	NO SUSPENDED ITEMS
					52000	71000	399000	445000	659000	
53	3	30012865830	10	10	224000	253000	263000	328000	473000	NO SUSPENDED ITEMS
					541000	690000	708000	782000	842000	
54	3	30012865830	10	10	799000	840000	846000	867000	964000	NO SUSPENDED ITEMS
					1320000	1156000	1276000	1343000	1389000	
55	13	09010865010	5	5	13430	15090	15530	15550	20570	NO SUSPENDED ITEMS
56	16	09010865010	3	3	4000	5400	5500			NO SUSPENDED ITEMS
57	16	09010865010	2	2	11400	12000				NO SUSPENDED ITEMS
58	16	09010865010	2	2	10000	11500				NO SUSPENDED ITEMS
59	16	09010865010	2	2	13300	14600				NO SUSPENDED ITEMS
60	16	09010860010	2	2	2600	2700				NO SUSPENDED ITEMS
61	16	09010865010	3	3	32000	39000	41000			NO SUSPENDED ITEMS
62	16	09010865010	2	2	39500	45800				NO SUSPENDED ITEMS
63	16	09010865010	2	2	82500	140000				NO SUSPENDED ITEMS
64	16	09010865010	2	2	10500	10700				NO SUSPENDED ITEMS
65	16	09010865010	2	2	7800	10000				NO SUSPENDED ITEMS
66	23	09110860010	2	2	16000	17000				NO SUSPENDED ITEMS
67	23	09110860010	2	2	37000	68000				NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND CYCLES TO SUSPENSION OF TESTING WITHOUT FAILURE FOR ALL GROUPS IN THE DATA COLLECTION

ITEM	REF	DESCRIPTIVE NO.	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
68	23	09110860010	2	2	81000	107000				NO SUSPENDED ITEMS
69	23	09110860010	2	2	136000	300000				NO SUSPENDED ITEMS
70	23	09110860010	2	2	9000	9100				NO SUSPENDED ITEMS
71	23	09110860010	2	2	41000	67000				NO SUSPENDED ITEMS
72	23	09110860010	2	2	91000	96000				NO SUSPENDED ITEMS
73	23	09110860010	2	2	221000	719000				NO SUSPENDED ITEMS
74	23	09110860010	2	2	17000	27000				NO SUSPENDED ITEMS
75	23	09110860010	2	2	4[illegible]100	55000				NO SUSPENDED ITEMS
76	23	09110860010	2	2	[illegible]000	228000				NO SUSPENDED ITEMS
77	23	09110860010	2	2	8900	9000				NO SUSPENDED ITEMS
78	23	09110860010	2	2	94000	125000				NO SUSPENDED ITEMS
79	23	09110860010	2	2	14000	16000				NO SUSPENDED ITEMS
80	23	09110860010	2	2	25000	64000				NO SUSPENDED ITEMS
81	23	09110860010	2	2	40000	82000				NO SUSPENDED ITEMS
82	23	09110860010	2	2	117000	140000				NO SUSPENDED ITEMS
83	23	09110860010	2	2	18000	21000				NO SUSPENDED ITEMS
84	23	09110860010	2	2	38000	42000				NO SUSPENDED ITEMS
85	23	09110860010	2	2	338000	592000				NO SUSPENDED ITEMS
86	23	09110860010	2	2	15000	43000				NO SUSPENDED ITEMS
87	23	09110860010	2	2	32000	37000				NO SUSPENDED ITEMS
88	23	09110860010	2	2	66000	174000				NO SUSPENDED ITEMS
89	23	09110860010	2	2	16000	18000				NO SUSPENDED ITEMS
90	23	09110860010	2	2	43000	53000				NO SUSPENDED ITEMS
91	23	09110860010	2	2	153030	177000				NO SUSPENDED ITEMS
92	11	10088865410	3	3	120900	295900	582300			NO SUSPENDED ITEMS
93	11	10088865410	2	2	23700	26400				NO SUSPENDED ITEMS
94	11	10088965410	2	2	10300	12000				NO SUSPENDED ITEMS
95	11	10088965410	2	2	370700	1272000				NO SUSPENDED ITEMS
96	11	10088965410	2	2	123400	287300				NO SUSPENDED ITEMS
97	57	05611860210	6	6	31000	34000	38000	36000	57000	NO SUSPENDED ITEMS
					59000					
98	57	06311860010	6	6	34000	36000	37000	41000	44000	NO SUSPENDED ITEMS
					46000					
99	21	03211060010	4	4	2800	3190	3560	3580		NO SUSPENDED ITEMS
100	21	03211060010	4	4	3800	4350	4630	4800		NO SUSPENDED ITEMS
101	21	03211060010	4	4	5550	5570	6460	6860		NO SUSPENDED ITEMS
102	21	03211060010	4	4	9680	10780	13060	13520		NO SUSPENDED ITEMS
103	21	03211060010	4	4	23990	30010	30600	36190		NO SUSPENDED ITEMS
104	21	03211060010	4	4	6180	6260	6540	6710		NO SUSPENDED ITEMS
105	21	03211060010	4	4	9680	9810	9950	12350		NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND CYCLES TO SUSPENSION OF TESTING WITHOUT FAILURE FOR ALL GROUPS IN THE DATA COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
106	21	03211060010	4	4	1147	11903	14983	15590		NO SUSPENDED ITEMS
107	21	03211060010	4	4	[illegible]	26460	31193	31200		NO SUSPENDED ITEMS
108	21	03211060010	5	5	60770	62120	68003	77[illegible]	77570	NO SUSPENDED ITEMS
109	21	03211060010	4	4	8990	9410	11150	1291		NO SUSPENDED ITEMS
110	21	03211060010	4	4	12383	12410	16600	23340		NO SUSPENDED ITEMS
111	21	03211060010	4	4	27910	28240	32960	34980		NO SUSPENDED ITEMS
112	21	03211060010	5	5	59210	64570	70770	77830	89620	NO SUSPENDED ITEMS
113	21	03211060010	4	4	24780	36410	37960	43740		NO SUSPENDED ITEMS
114	21	03211060010	4	4	42610	72790	83013	95650		NO SUSPENDED ITEMS
115	21	03211060010	4	4	109620	206790	277963	286220		NO SUSPENDED ITEMS
116	21	03211060010	4	4	111710	114690	164953	171200		NO SUSPENDED ITEMS
117	21	03211060010	4	4	195150	363160	531593	541850		NO SUSPENDED ITEMS
118	23	09110860010	2	2	250000	398300				NO SUSPENDED ITEMS
119	23	09110860010	2	2	12000	12100				NO SUSPENDED ITEMS
120	23	09110860010	2	2	17000	46000				NO SUSPENDED ITEMS
121	23	09110860010	2	2	30000	68000				NO SUSPENDED ITEMS
122	23	09110860010	2	2	164000	283000				NO SUSPENDED ITEMS
123	23	09110860010	2	2	175000	262000				NO SUSPENDED ITEMS
124	23	09110860010	2	2	12000	13000				NO SUSPENDED ITEMS
125	23	09110860010	2	2	40000	62000				NO SUSPENDED ITEMS
126	23	09110860010	3	3	95000	97000	105[illegible]			NO SUSPENDED ITEMS
127	23	09110860010	3	3	243000	381000	575[illegible]			NO SUSPENDED ITEMS
128	23	09110860010	2	2	13000	16000				NO SUSPENDED ITEMS
129	23	09110860010	2	2	26500	26100				NO SUSPENDED ITEMS
130	23	09110860010	2	2	65000	70000				NO SUSPENDED ITEMS
131	23	09110860010	3	3	53000	287000	[illegible]251000			NO SUSPENDED ITEMS
132	23	09110860010	2	2	148000	411000				NO SUSPENDED ITEMS
133	23	09110860010	2	2	93000	95000				NO SUSPENDED ITEMS
134	23	09110860010	2	2	156000	212000				NO SUSPENDED ITEMS
135	23	09110860010	2	2	23000	26000				NO SUSPENDED ITEMS
136	23	09110860010	[illegible]	2	45000	95000				NO SUSPENDED ITEMS
137	23	[illegible]	2	2	61000	254000				NO SUSPENDED ITEMS
138	23	09110860010	2	2	11030	12000				NO SUSPENDED ITEMS
139	23	[illegible]	2	2	21000	51000				NO SUSPENDED ITEMS
140	23	[illegible]	2	2	182000	249000				NO SUSPENDED ITEMS
141	23	[illegible]	[illegible]	[illegible]	21000	76000				NO SUSPENDED ITEMS
142	23	[illegible]	[illegible]	[illegible]	38000	83000				NO SUSPENDED ITEMS
143	23	[illegible]	[illegible]	[illegible]	20000	25000				NO SUSPENDED ITEMS
144	[illegible]	[illegible]	[illegible]	2	70000	93000				NO SUSPENDED ITEMS
145	[illegible]	[illegible]	[illegible]	[illegible]	23000	33000				NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND CYCLES TO SUSPENSION OF TESTING WITHOUT FAILURE FOR ALL GROUPS IN THE DATA COLLECTION

ITEM	[illegible]	MATERIAL	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
[illegible]	[illegible]	[illegible]	2	2	57000	233000				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	2	2	10000	11000				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	2	2	28000	54000				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	2	2	84000	176000				NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	601	640	1425	2044	5055	NO SUSPENDED ITEMS
241	1	[illegible]	[illegible]	[illegible]	901	1081	1386	1742	2763	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	786	1509	1866	2476	2621	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	561	915	965	1072	1101	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	1215	1519	1897	2424	2844	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	500	610	806	[illegible]	874	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	341	362	393	465	537	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	150	250	263	324	350	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	171	175	183	212	315	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	343	450	516	500	664	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	37	119	140	172	183	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	142	215	226	277	303	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	620	761	914	975	1016	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	521	531	663	820	1601	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	491	560	893	1033	1203	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	474	763	1304	[illegible]	1883	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	191	228	247	263	296	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	388	413	573	[illegible]	856	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	485	672	748	753	813	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	1245	1650	1866	2274	2460	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	100	130	240	250	350	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	90	160	183	193	230	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	147	263	336	415	501	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	450	450	562	783	1155	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	156	168	177	173	200	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	125	184	199	232	242	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	384	425	443	678	708	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	360	430	463	443	1033	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	360	478	575	[illegible]	1187	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	786	1071	1221	1331	1390	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	494	728	766	936	1021	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	451	476	655	761	881	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	503	900	1513	1440	2363	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	777	1351	1442	1501	1766	NO SUSPENDED ITEMS
[illegible]	1	[illegible]	[illegible]	[illegible]	485	502	503	[illegible]	563	NO SUSPENDED ITEMS
[illegible]	1	[illegible]			1332	1356				NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND CYCLES TO SUSPENSION OF TESTING WITHOUT FAILURE FOR ALL GROUPS IN THE DATA COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION		
320	1	04010860010	5	5	2098500	3979800	5440000	6378000	8109720	NO SUSPENDED ITEMS		
323	3	30012865830	10	10	340000	375000	766000	967000	1388000	NO SUSPENDED ITEMS		
					1515000	4611000	4694000	12838000	22910000			
324	3	30012865830	10	10	11348000	11785000	11924000	12560000	15223000	NO SUSPENDED ITEMS		
					18995000	19132000	23875000	27558000	32279000			
325	3	30012865830	9	9	2571000	7020000	18389000	60528000	61015000	NO SUSPENDED ITEMS		
					88493000	107573000	118263000	150412000				
326	3	30012865830	9	5	9888000	29402000	278180000	309694000	599517000	501931000	512303000	592748000
										658449000		
327	3	30012865830	10	10	242000	1051000	1107000	1122000	1552000	NO SUSPENDED ITEMS		
					1565000	1880000	2212000	3732000	6274000			
328	3	30012865830	10	10	1289000	1296000	1772000	2429000	3033000	NO SUSPENDED ITEMS		
					3074000	9625000	12840000	13434000	71645000			
329	3	30012865830	9	9	1390000	4938000	11440000	48090000	49208000	NO SUSPENDED ITEMS		
					63237000	108446000	240710000	268102000				
330	3	30012865830	10	9	11703000	108395000	118135000	240908000	354455000	515286000		
					364450000	432442000	486409000	488868000				
331	3	30012865830	10	10	735000	1116000	1132000	1430000	1439000	NO SUSPENDED ITEMS		
					1445000	1479000	1490000	1766000	2449000			
332	3	30012865830	10	9	1658000	1668000	2045000	2249000	2845000	999999999		
					5439000	8755000	32072000	33550000				
333	3	30012865830	10	6	3611000	3682000	11485000	13089000	177740000	503136000	503823000	515239000
					122595000					787812000		
334	3	30012865830	10	7	2758000	2965000	5764000	34984000	197869000	616445000	715839000	999999999
					267124000	505327000						
336	11	10088865410	3	2	282300	1079400				30875000		
337	11	10088965410	2	2	1188700	1771600				NO SUSPENDED ITEMS		
338	21	03211060010	4	4	1185350	1241840	1289160	1411570		NO SUSPENDED ITEMS		
339	21	03211060010	4	4	1982590	2500000	6061190	6717590		NO SUSPENDED ITEMS		
400	3	30012865830	9	9	79000	81000	91000	100000	105000	NO SUSPENDED ITEMS		
					109000	110000	110000	130000				
401	3	30012865830	9	9	68000	202000	234000	334000	370000	NO SUSPENDED ITEMS		
					412000	921000	1452000	1579000				
402	3	30012865830	4	4	271000	271000	293000	346000		NO SUSPENDED ITEMS		
403	3	30012865830	5	5	304000	397000	483000	594000	667000	NO SUSPENDED ITEMS		
404	3	30012865830	4	4	74000	92000	100000	100000		NO SUSPENDED ITEMS		
405	3	30012865830	5	5	262000	331000	497000	549000	609000	NO SUSPENDED ITEMS		
406	3	30012865830	4	4	549000	978000	990000	1050000		NO SUSPENDED ITEMS		

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	KEY	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
407	3	09012865830	15	15	168620	175500	181135	199250	200740	NO SUSPENDED ITEMS
					203860	208560	213300	214060	220280	
					222150	225530	247060	247700	280115	
408	13	09010865080	6	6	97380	99170	114450	121450	125690	NO SUSPENDED ITEMS
					142120					
409	13	09010865080	6	6	115111	115560	115759	115759	123035	NO SUSPENDED ITEMS
					140900					
410	13	09010865090	12	12	97380	99170	114450	115111	115560	NO SUSPENDED ITEMS
					115759	115759	121450	123035	125690	
					140900	142120				
411	13	09010865050	25	25	12376	12410	13498	13498	13940	NO SUSPENDED ITEMS
					13974	14212	14212	14722	14756	
					14756	14756	14926	15232	15300	
					15470	17631	18258	19109	19312	
					19550	19788	19890	20196	20842	
412	13	09010865080	6	6	42280	52345	52379	57709	57709	NO SUSPENDED ITEMS
					63494					
413	13	09010865080	6	6	44392	46092	48055	48055	51675	NO SUSPENDED ITEMS
					56202					
414	13	09010865080	7	7	38423	40103	48055	48055	52345	NO SUSPENDED ITEMS
					57709	57709				
415	13	09010865080	6	6	40501	46125	46125	48025	48075	NO SUSPENDED ITEMS
					52345					
416	13	09010865080	6	6	30926	34554	36381	48056	52344	NO SUSPENDED ITEMS
					55997					
417	13	09010865080	31	31	30926	34554	36381	38423	40103	NO SUSPENDED ITEMS
					40501	42280	44392	46092	46125	
					46125	48025	48025	48055	48055	
					48055	48055	48056	51675	52344	
					52345	52345	52345	52379	55997	
					56202	57709	57709	57709	57709	
					63494					
418	13	09010865080	6	6	108529	115598	131617	131649	131649	NO SUSPENDED ITEMS
					142289					
419	13	09010865080	6	6	40501	46125	46125	48025	48025	NO SUSPENDED ITEMS
					52346					
420	13	09010865050	6	6	321977	371651	397083	404903	431695	NO SUSPENDED ITEMS
					460595					
421	13	09010865050	6	6	73209	87457	89389	96966	102431	NO SUSPENDED ITEMS
					106846					

LISTED NUMBERS OF CYCLES TO FAILURE AND
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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
422	13	09010865050	6	6	16964	19074	20604	20604	22202	NO SUSPENDED ITEMS
					22848					
423	13	09010865050	6	6	159976	167049	172914	198202	198202	NO SUSPENDED ITEMS
					229632					
424	13	09010865050	6	6	35530	35530	36414	37774	39066	NO SUSPENDED ITEMS
					43526					
425	13	09010865050	6	6	32470	33660	35495	36822	40698	NO SUSPENDED ITEMS
					40766					
426	13	09010865050	6	6	451075	480100	495207	496805	532165	NO SUSPENDED ITEMS
					592111					
427	13	09010865050	6	6	87458	99567	100775	107987	115606	NO SUSPENDED ITEMS
					119000					
428	13	09010865050	6	6	479873	478873	655373	655373	655373	NO SUSPENDED ITEMS
					763099					
429	13	09010865050	6	6	100576	100576	100576	100576	121733	NO SUSPENDED ITEMS
					140023					
430	13	09010865050	6	6	76923	84780	91578	93013	95878	NO SUSPENDED ITEMS
					101310					
431	13	09010865050	6	6	12376	12410	13495	15232	19550	NO SUSPENDED ITEMS
					19890					
432	13	09010865050	7	7	13498	13974	15300	15470	19108	NO SUSPENDED ITEMS
					19312	19788				
433	13	09010865050	6	6	14722	14756	14756	14756	14926	NO SUSPENDED ITEMS
					17631					
434	13	09010865050	6	6	13940	14212	14212	19256	20196	NO SUSPENDED ITEMS
					20842					
435	15	09010865050	6	6	54083	54083	55766	59815	64694	NO SUSPENDED ITEMS
					69911					
436	15	09010865050	6	6	47065	49578	52672	53228	64413	NO SUSPENDED ITEMS
					64653					
437	15	09010865050	6	6	54651	59805	62690	69932	69902	NO SUSPENDED ITEMS
					72748					
438	15	09010865050	7	7	32174	38221	38221	39221	42997	NO SUSPENDED ITEMS
					46300	60666				
439	15	09010865080	7	7	6978	46978	46978	54797	60586	NO SUSPENDED ITEMS
					60586	79069				
440	15	09010865050	6	6	17393	20357	20706	20980	21159	NO SUSPENDED ITEMS
					23412					
441	15	09010865080	6	6	29511	32462	32466	35696	35705	NO SUSPENDED ITEMS
					40457					

LISTED NUMBERS OF CYCLES TO FAILURE AND CYCLES TO SUSPENSION OF TESTING WITHOUT FAILURE FOR ALL GROUPS IN THE DATA COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
442	15	09010865080	8	8	147705	156295	160191	161904	162604	NO SUSPENDED ITEMS
					171175	184430	191054			
443	15	09010865080	6	6	192131	215564	227606	228760	251000	NO SUSPENDED ITEMS
					285454					
444	15	09010865080	6	6	152298	158592	164878	211978	214201	NO SUSPENDED ITEMS
					228124					
445	15	09010865080	6	6	96148	95579	105557	140207	168979	NO SUSPENDED ITEMS
					191360					
446	15	09010865080	6	6	100347	102741	103568	105004	115572	NO SUSPENDED ITEMS
					135515					
447	1	04010860050	4	4	1453000	1470000	1792000	1936000		NO SUSPENDED ITEMS
448	1	04010860070	5	5	458000	1030000	1394000	2046000	2105000	NO SUSPENDED ITEMS
449	1	04010860070	5	5	3178000	3777000	4169000	4918000	5070000	NO SUSPENDED ITEMS
450	1	04010860070	5	5	4553000	5386000	5390000	5874000	10056000	NO SUSPENDED ITEMS
451	1	04010860050	6	6	170000	200000	213000	239000	252000	NO SUSPENDED ITEMS
					326000					
452	1	04010860070	5	5	211000	228000	254000	289000	305000	NO SUSPENDED ITEMS
453	1	04010860050	7	7	239000	248000	326000	335000	396000	NO SUSPENDED ITEMS
					457000	652000				
454	1	04010860070	8	8	145000	153000	164000	207000	304000	NO SUSPENDED ITEMS
					306000	353000	498000			
455	1	04010860070	5	5	415000	441000	470000	814000	928000	NO SUSPENDED ITEMS
456	1	04010860070	5	5	224000	257000	288000	289000	319000	NO SUSPENDED ITEMS
457	1	04010860050	6	6	39200	52200	52200	56600	56600	NO SUSPENDED ITEMS
					95700					
458	1	04010860070	6	6	41300	55500	58200	63000	63000	NO SUSPENDED ITEMS
					68000					
459	1	04010860050	10	10	228000	239000	240000	254000	260000	NO SUSPENDED ITEMS
					262000	277000	300000	309000	359000	
460	1	04010860070	5	5	536000	780000	808000	985000	1020000	NO SUSPENDED ITEMS
461	1	04010850050	4	4	157000	169000	203000	259000		NO SUSPENDED ITEMS
462	1	04010860070	5	5	118000	134000	141000	147000	187000	NO SUSPENDED ITEMS
463	1	04010860050	6	6	449000	496000	500000	552000	579000	NO SUSPENDED ITEMS
					783000					
464	1	04010860070	6	6	748000	775000	900000	1010000	1258000	NO SUSPENDED ITEMS
					1109000					
465	1	04010860050	7	7	17600	22000	26400	26400	26400	NO SUSPENDED ITEMS
					30800	44000				
466	1	04010860070	5	5	9700	12900	12900	15000	19300	NO SUSPENDED ITEMS
467	1	04010860070	5	5	9200	12300	12300	13300	17400	NO SUSPENDED ITEMS

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
468	1	04010860050	5	5	9100	9800	10300	12100	135000	NO SUSPENDED ITEMS
469	1	04010860070	5	5	454000	571000	1092000	1242000	1694000	NO SUSPENDED ITEMS
470	1	04010860070	5	5	83000	84000	110000	134000	138000	NO SUSPENDED ITEMS
471	1	04010860070	5	5	117000	118000	149000	151000	191000	NO SUSPENDED ITEMS
472	1	04010860070	8	8	177000	200000	221000	259000	269000	NO SUSPENDED ITEMS
					276000	301000	338000			
540	3	30012865830	4	4	1200000	3733000	17741000	21681000		NO SUSPENDED ITEMS
541	3	30012865830	5	5	29101000	29279000	47911000	74000000	394512000	NO SUSPENDED ITEMS
542	3	30012865830	3	3	1410000	1780000	3371000			NO SUSPENDED ITEMS
543	3	30012865830	3	3	1204000	1993000	2030000			NO SUSPENDED ITEMS
544	3	30012865830	3	3	4480000	4990000	5494000			NO SUSPENDED ITEMS
545	3	30012865830	5	5	100000	879000	1316000	1711000	2347000	NO SUSPENDED ITEMS
546	3	30012865830	5	5	2527000	4834000	6933000	35543000	38000000	NO SUSPENDED ITEMS
547	3	30012865830	5	5	47600000	44868000	153059000	255580000	337566000	NO SUSPENDED ITEMS
548	3	30012865830	14	14	1554400	1668837	1675620	1773000	1781236	NO SUSPENDED ITEMS
					1789600	1893000	1906420	1989780	2004547	
					2019440	2116700	2328710	2450000		
549	3	30012865830	10	10	743350	865880	968290	1106390	1109730	NO SUSPENDED ITEMS
					1110100	1326330	1337930	1438740	1906720	
600	1	04010860010	5	5	100800	135000	203400	302400	385200	NO SUSPENDED ITEMS
601	1	04010860010	5	5	37440	91800	117000	124200	3700000	NO SUSPENDED ITEMS
602	1	04010860010	5	5	484200	525600	698400	1674000	2719600	NO SUSPENDED ITEMS
603	1	04010860010	5	5	9540	12600	14400	41400	52200	NO SUSPENDED ITEMS
604	1	04010860010	5	5	14590	40140	102780	147600	148500	NO SUSPENDED ITEMS
605	1	04010860010	5	5	185000	248000	390400	651600	691700	NO SUSPENDED ITEMS
607	1	04010860010	5	5	1640	2215	3215	4500	9011	NO SUSPENDED ITEMS
608	1	04010860010	5	5	28800	45000	66600	72000	73800	NO SUSPENDED ITEMS
609	1	04010860010	5	5	28800	36000	36000	43200	88200	NO SUSPENDED ITEMS
610	1	04010860010	5	5	185400	352800	658800	1420200	3216600	NO SUSPENDED ITEMS
611	1	04010860010	5	5	48600	55800	144000	824760	888480	NO SUSPENDED ITEMS
612	21	03211[illegible]010	4	4	310720	416020	445970	525560		NO SUSPENDED ITEMS
641	1	04010860010	5	5	163000	189000	1306800	1998000	3601000	NO SUSPENDED ITEMS
650	3	300128[illegible]	9	9	75000	76000	103000	105000	134000	NO SUSPENDED ITEMS
					186000	190000	209000	369000		
651	3	300128[illegible]	10	10	179000	208000	219000	266000	298000	NO SUSPENDED ITEMS
					314000	401000	430000	763000	929000	
652	3	30012855830	10	10	319000	374000	504000	600000	665000	NO SUSPENDED ITEMS
					665000	776000	776000	2993000	3844000	

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ITEM	FFF DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
653	3 30012855830	11	11	490000	491000	803000	888000	1021000	NO SUSPENDED ITEMS
				1034000	1160000	1249000	1748000	1809000	
				3643000					
654	3 30012855830	4	4	520000	574000	606000	1293000		NO SUSPENDED ITEMS
655	3 30012855830	5	5	529000	1000000	1033000	2718000	2778000	NO SUSPENDED ITEMS
656	11 10088855410	2	2	72000	161000				NO SUSPENDED ITEMS
657	11 10088855410	2	2	42300	58400				NO SUSPENDED ITEMS
658	11 10088955410	2	2	58900	1269400				NO SUSPENDED ITEMS
659	11 10088955410	2	2	79700	121400				NO SUSPENDED ITEMS
660	11 10088955410	2	2	54100	142000				NO SUSPENDED ITEMS
661	11 10088955410	2	2	19100	28100				NO SUSPENDED ITEMS
662	11 10088955410	2	2	8800	14000				NO SUSPENDED ITEMS
663	57 06311855020	7	7	25000	26000	29000	29000	30000	NO SUSPENDED ITEMS
				30000	31000				
664	57 05611855220	6		37000	52000	52000	58000	58000	NO SUSPENDED ITEMS
				59000					
665	22 06411055010	4	4	11970	12620	12780	14920		NO SUSPENDED ITEMS
666	22 06411055010	4	4	47980	51740	54630	58470		NO SUSPENDED ITEMS
667	22 06411055010	4	4	14580	14820	15640	16150		NO SUSPENDED ITEMS
668	22 06411055010	4	4	45150	46460	47550	53410		NO SUSPENDED ITEMS
669	22 06411055010	4	4	11970	12620	12780	14920		NO SUSPENDED ITEMS
670	22 06411055010	4	4	47980	51740	54430	58470		NO SUSPENDED ITEMS
671	22 06411055010	4	4	13890	14520	15180	15740		NO SUSPENDED ITEMS
672	22 06411055010	4	4	41550	43570	47810	47940		NO SUSPENDED ITEMS
673	22 06411055010	2	2	15770	17560				NO SUSPENDED ITEMS
674	22 06411055010	2	2	51480	53300				NO SUSPENDED ITEMS
675	22 06411055010	4	4	15620	16290	16310	16450		NO SUSPENDED ITEMS
676	22 06411055010	4	4	43590	50580	50890	54790		NO SUSPENDED ITEMS
677	22 06411055010	4	4	12560	12870	13650	13860		NO SUSPENDED ITEMS
678	22 06411055010	4	4	43670	52160	53520	54280		NO SUSPENDED ITEMS
679	22 06411055010	5	5	12630	14120	16360	14640	17010	NO SUSPENDED ITEMS
680	22 06411055010	5	5	39680	41450	47000	50550	59250	NO SUSPENDED ITEMS
681	22 06411055010	4	4	13720	15140	15630	17220		NO SUSPENDED ITEMS
682	22 06411055010	4	4	53280	56330	59110	59610		NO SUSPENDED ITEMS
683	22 06411055010	5	5	12000	15190	15260	15910	17980	NO SUSPENDED ITEMS
684	22 06411055010	5	5	47950	54050	55470	55580	57370	NO SUSPENDED ITEMS
685	22 06411055010	4	4	11950	12510	13840	14840		NO SUSPENDED ITEMS
686	22 06411055010	4	4	44770	48500	48620	56010		NO SUSPENDED ITEMS
687	22 06411055010	4	4	2810	2820	3420	3660		NO SUSPENDED ITEMS
688	22 06411055010	4	4	50730	53050	68480	68910		NO SUSPENDED ITEMS

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689	22	06411055010	5	5	2610	2810	2900	3020	3730	NO SUSPENDED ITEMS
690	22	06411055010	4	4	35960	42060	47710	55270		NO SUSPENDED ITEMS
691	22	06411055010	4	4	5170	5280	5810	6120		NO SUSPENDED ITEMS
692	22	06411055010	5	5	60580	65970	68150	77250	86565	NO SUSPENDED ITEMS
693	22	06411055010	4	4	3050	3600	4170	4360		NO SUSPENDED ITEMS
694	22	0641105 010	4	4	59030	60085	63300	74820		NO SUSPENDED ITEMS
695	22	0641105 010	4	4	2970	3480	3560	3730		NO SUSPENDED ITEMS
696	22	06411055010	4	4	54130	57800	60310	60830		NO SUSPENDED ITEMS
697	22	06411055010	4	4	2820	3245	3300	3660		NO SUSPENDED ITEMS
698	22	06411055010	4	4	59540	59820	64240	68250		NO SUSPENDED ITEMS
699	22	06411055010	4	4	3020	3470	3545	3910		NO SUSPENDED ITEMS
700	22	06411055010	4	4	53700	63450	73770	74530		NO SUSPENDED ITEMS
701	22	06411055010	4	4	1960	1970	2120	2200		NO SUSPENDED ITEMS
702	22	06411055010	4	4	53280	56240	58710	62765		NO SUSPENDED ITEMS
703	22	06411055010	4	4	1965	2085	2160	2390		NO SUSPENDED ITEMS
704	22	06411055010	4	4	43450	43810	49515	52055		NO SUSPENDED ITEMS
705	22	06411055010	4	4	2390	2690	2900	2930		NO SUSPENDED ITEMS
706	22	06411055010	4	4	46240	48500	53610	55390		NO SUSPENDED ITEMS
707	22	06411055010	4	4	3790	3860	4175	4370		NO SUSPENDED ITEMS
708	22	06411055010	4	4	59980	74770	75070	77550		NO SUSPENDED ITEMS
709	22	06411055010	4	4	38270	40680	48420	54600		NO SUSPENDED ITEMS
710	22	06411055010	4	4	68090	72730	74845	75645		NO SUSPENDED ITEMS
711	22	06411055010	3	3	50758	60490	65060			NO SUSPENDED ITEMS
712	22	06411055010	4	4	53400	54050	57640	62370		NO SUSPENDED ITEMS
713	22	06411055010	4	4	669250	856610	928735	973500		NO SUSPENDED ITEMS
714	22	06411055010	4	4	60930	68370	69870	85910		NO SUSPENDED ITEMS
715	22	06411055010	4	4	63200	65120	69875	78670		NO SUSPENDED ITEMS
716	22	06411055010	4	4	51690	54700	55250	66800		NO SUSPENDED ITEMS
717	22	06411055010	4	4	51830	59140	63040	64630		NO SUSPENDED ITEMS
718	22	06411055010	4	4	52110	59160	60230	60550		NO SUSPENDED ITEMS
719	22	06411055010	4	4	41330	44020	48380	55280		NO SUSPENDED ITEMS
720	22	06411055010	4	4	49110	55680	58420	60920		NO SUSPENDED ITEMS
721	22	06411055010	4	4	54080	54610	55790	56580		NO SUSPENDED ITEMS
722	22	06411055010	4	4	52620	55400	55610	55780		NO SUSPENDED ITEMS
723	22	06411055010	4	4	46090	51040	54180	61970		NO SUSPENDED ITEMS
724	22	03211055010	4	4	37270	38600	42650	44270		NO SUSPENDED ITEMS
725	22	03211055010	4	4	32890	34070	34130	35240		NO SUSPENDED ITEMS
726	22	03211055010	4	4	206250	355240	587140	735750		NO SUSPENDED ITEMS
727	22	03211055010	5	5	27960	42430	46110	56050	57040	NO SUSPENDED ITEMS
728	22	03211055010	4	4	26760	30390	33520	35400		NO SUSPENDED ITEMS

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
729	22	03211055010	4	4	378510	496770	526620	534740		NO SUSPENDED ITEMS
730	22	03211055010	4	4	20850	27940	32150	32190		NO SUSPENDED ITEMS
731	22	03211055010	4	4	408630	430030	453610	498950		NO SUSPENDED ITEMS
732	22	03211055010	4	4	30710	37800	40150	41640		NO SUSPENDED ITEMS
733	22	03211055010	4	4	19150	27070	28150	28860		NO SUSPENDED ITEMS
734	22	03211055010	4	4	441170	456380	489580	591950		NO SUSPENDED ITEMS
735	22	06411055010	4	4	28150	29550	30710	31350		NO SUSPENDED ITEMS
736	22	06411055010	4	4	26570	26590	26650	33390		NO SUSPENDED ITEMS
737	22	06411055010	4	4	25330	26290	26950	28940		NO SUSPENDED ITEMS
738	22	06411055010	4	4	31470	33500	34230	37380		NO SUSPENDED ITEMS
739	22	06411055010	4	4	27270	30220	30620	33350		NO SUSPENDED ITEMS
740	22	06411055010	4	4	29650	33490	33540	34040		NO SUSPENDED ITEMS
741	22	06411055010	4	4	19460	21980	27150	32580		NO SUSPENDED ITEMS
742	22	06411055010	4	4	39400	41950	43200	43210		NO SUSPENDED ITEMS
743	22	06411055010	2	2	38530	38730				NO SUSPENDED ITEMS
744	22	06411055010	2	2	38530	39440				NO SUSPENDED ITEMS
745	22	06411055010	4	4	34700	35060	37040	41725		NO SUSPENDED ITEMS
746	22	06411055010	4	4	37960	39010	42590	46940		NO SUSPENDED ITEMS
747	22	06411055010	4	4	40160	40320	43550	49140		NO SUSPENDED ITEMS
748	22	06411055010	4	4	28170	31720	35240	36700		NO SUSPENDED ITEMS
749	22	06411055010	4	4	18230	19450	20240	21250		NO SUSPENDED ITEMS
750	22	06411055010	[illegible]	[illegible]	18820	21890	22570	25630	26130	NO SUSPENDED ITEMS
751	22	06411055010	4	4	19950	22600	28530	30620		NO SUSPENDED ITEMS
752	22	06411055010	4	4	22910	23340	23960	25430		NO SUSPENDED ITEMS
753	22	06411055010	[illegible]	[illegible]	15800	16730	20300	20925	21090	NO SUSPENDED ITEMS
754	22	06411055010	[illegible]	[illegible]	21980	22170	28460	28940	29190	NO SUSPENDED ITEMS
755	22	06411055010	4	4	20640	21990	22470	31940		NO SUSPENDED ITEMS
756	22	06411055010	4	4	16940	17450	19640	21340		NO SUSPENDED ITEMS
757	22	06411055010	4	4	17940	18140	19340	20440		NO SUSPENDED ITEMS
758	22	06411055010	4	4	12420	12620	14530	15230		NO SUSPENDED ITEMS
759	22	06411055010	4	4	11500	15220	15410	18910		NO SUSPENDED ITEMS
760	22	06411055010	4	4	22920	24220	24520	28720		NO SUSPENDED ITEMS
761	22	06411055010	4	4	22100	24510	28700	30400		NO SUSPENDED ITEMS
762	22	06411055010	4	4	21640	[illegible]	[illegible]	22940		NO SUSPENDED ITEMS
763	22	06411055010	4	4	17240	[illegible]	[illegible]	21530		NO SUSPENDED ITEMS
764	22	06411055010	4	4	20930	23050	23380	25070		NO SUSPENDED ITEMS
765	22	06411055010	4	4	19560	20950	24290	25970		NO SUSPENDED ITEMS
766	22	06411055010	4	4	20550	20750	20930	24110		NO SUSPENDED ITEMS
767	22	06411055010	4	4	29125	23720	29500	29540		NO SUSPENDED ITEMS
768	22	06411055010	4	4	29610	29900	31960	35765		NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
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FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
769	22	06411055010	4	4	37485	38770	39710	42700		NO SUSPENDED ITEMS
770	22	06411055010	4	4	24540	30080	30090	32600		NO SUSPENDED ITEMS
771	22	06411055010	4	4	27465	32430	34940	34950		NO SUSPENDED ITEMS
772	22	06411055010	4	4	32850	37820	38085	38210		NO SUSPENDED ITEMS
773	22	06411055010	4	4	37670	37685	37800	37810		NO SUSPENDED ITEMS
774	22	06411055010	4	4	30040	37530	37590	40240		NO SUSPENDED ITEMS
775	22	06411055010	4	4	47090	52280	53210	55570		NO SUSPENDED ITEMS
776	22	06411055010	4	4	40450	40650	40660	40685		NO SUSPENDED ITEMS
777	22	06411055010	4	4	730100	750080	760080	820090		NO SUSPENDED ITEMS
778	22	06411055010	4	4	699630	739930	749900	799700		NO SUSPENDED ITEMS
779	22	06411055010	4	4	520030	540330	634730	670330		NO SUSPENDED ITEMS
780	22	06411055010	4	4	490020	500070	539460	629770		NO SUSPENDED ITEMS
781	22	06411055010	3	3	378300	410470	560260			NO SUSPENDED ITEMS
782	22	06411055010	3	3	487000	489510	497700			NO SUSPENDED ITEMS
783	22	06411055010	5	5	159440	374060	735020	1060740	1074840	NO SUSPENDED ITEMS
784	22	06411055010	4	4	522370	523570	524100	525080		NO SUSPENDED ITEMS
785	22	06411055010	4	4	538665	602120	606675	1005260		NO SUSPENDED ITEMS
786	22	06411055010	4	4	576500	589840	590470	594480		NO SUSPENDED ITEMS
787	22	06411055010	4	4	435140	580900	600400	616665		NO SUSPENDED ITEMS
788	22	06411055010	4	4	479360	549620	566030	585220		NO SUSPENDED ITEMS
789	22	06411055010	4	4	400140	472160	480080	512150		NO SUSPENDED ITEMS
790	22	06411055010	4	4	452000	468020	479960	569950		NO SUSPENDED ITEMS
791	22	06411055010	4	4	153310	200480	202300	202840		NO SUSPENDED ITEMS
792	22	06411055010	4	4	185970	187830	193080	197600		NO SUSPENDED ITEMS
793	22	06411055010	4	4	160710	180950	181350	190920		NO SUSPENDED ITEMS
794	22	06411055010	4	4	158070	169050	176580	179680		NO SUSPENDED ITEMS
795	22	06411055010	4	4	159240	162120	170160	186140		NO SUSPENDED ITEMS
796	22	06411055010	4	4	163870	168880	168900	198920		NO SUSPENDED ITEMS
797	22	06411055010	4	4	710210	995990	1038310	1114830		NO SUSPENDED ITEMS
798	22	03211055010	3	3	399140	419990	462520			NO SUSPENDED ITEMS
799	22	03211055010	4	4	156530	226820	227510	228220		NO SUSPENDED ITEMS
800	22	03211055010	4	4	223110	251750	276930	298370		NO SUSPENDED ITEMS
801	22	03211055010	4	4	85440	92690	92815	95950		NO SUSPENDED ITEMS
802	22	03211055010	4	4	134500	135610	138530	142150		NO SUSPENDED ITEMS
803	22	03211055010	4	4	90080	87110	104600	153870		NO SUSPENDED ITEMS
804	22	03211055010	4	4	126960	139260	146750	147030		NO SUSPENDED ITEMS
805	22	03211055010	4	4	35410	78510	83240	89410		NO SUSPENDED ITEMS
806	22	03211055010	4	4	129210	132310	133580	136140		NO SUSPENDED ITEMS
807	22	03211055010	8	8	715780	815120	874440	1009280	1040730	NO SUSPENDED ITEMS
					1046570	1064180	1362480			

LISTED NUMBERS OF CYCLES TO FAILURE AND CYCLES TO SUSPENSION OF TESTING WITHOUT FAILURE FOR ALL GROUPS IN THE DATA COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION		
808	22	03211055010	4	4	95920	185790	195140	219600		NO SUSPENDED ITEMS		
809	22	06411055010	4	4	22250	17440	44940	49735		NO SUSPENDED ITEMS		
810	22	03211055010	3	3	400470	459330	574900			NO SUSPENDED ITEMS		
811	22	06411055010	4	4	2660	3030	3210	3850		NO SUSPENDED ITEMS		
812	22	06411055010	4	4	700700	700710	800750	901380		NO SUSPENDED ITEMS		
930	3	30012855830	10	10	902000	979000	1738000	1876000	3005000	NO SUSPENDED ITEMS		
					6902000	7449000	16223000	26681000	42229000			
932	3	30012855830	11	10	2590000	16089000	25108000	27358000	57408000	509037000		
					67390000	85167000	196662000	243668000	291754000			
933	3	30012855830	10	6	2310000	2408300	3456000	4090000	8161000	504590000	506378000	513555000
					104613000					517318000		
934	3	30012855830	9	2	137207000	205282000				505082000	516099000	531763000
										544945000	547322000	590857000
										863224000		
936	3	30012855830	5	5	2630000	4632000	8070000	22652000	349080000	NO SUSPENDED ITEMS		
937	3	30012855830	4	4	1194000	1525000	3410000	10121000		NO SUSPENDED ITEMS		
938	3	30012855830	7	6	1265000	1354000	2230000	3058000	455000000	405467000		
					64256000							
939	3	30012855830	2	2	90444000	96170000				NO SUSPENDED ITEMS		
940	3	30012855830	5	5	1966000	3821000	4944000	20594000	219250000	NO SUSPENDED ITEMS		
941	3	30012855830	5	5	540000	1433000	51282000	58277000	944200000	NO SUSPENDED ITEMS		
942	3	30012855830	5	5	3060000	3065000	10640000	78816000	193961000	NO SUSPENDED ITEMS		
943	3	30012855830	3	3	2470000	5190000	6240000			NO SUSPENDED ITEMS		
944	3	30012855830	5	5	2909000	4591000	12780000	175183000	202210000	NO SUSPENDED ITEMS		
945	3	30012855830	4	4	1325000	1773000	2501000	3370000		NO SUSPENDED ITEMS		
946	3	30012855830	2	2	61080000	108882000				NO SUSPENDED ITEMS		
947	3	30012855830	6	6	2687000	9341000	10493000	116334000	237102000	NO SUSPENDED ITEMS		
					259006000							
948	3	30012855830	3	3	1113000	1202000	2015000			NO SUSPENDED ITEMS		
949	3	30012855830	3	3	566000	4291000	219102000			NO SUSPENDED ITEMS		
950	3	30012855930	3	3	25138000	29194000	146551000			NO SUSPENDED ITEMS		
952	11	10088855410	2	2	358000	16646500				NO SUSPENDED ITEMS		
953	11	10088855410	2	2	701000	1207600				NO SUSPENDED ITEMS		
954	11	10088855410	2	2	403700	3656100				NO SUSPENDED ITEMS		
955	11	10088855410	2	2	485700	4328600				NO SUSPENDED ITEMS		
956	22	06411055010	4	4	1182125	1532990	1928870	2234550		NO SUSPENDED ITEMS		
957	22	06411055010	4	4	2012660	2436020	2583830	2718000		NO SUSPENDED ITEMS		
958	22	06411055010	4	4	946970	1042680	1383520	2285000		NO SUSPENDED ITEMS		
959	22	06411055010	4	4	1119280	1444320	2084990	3094980		NO SUSPENDED ITEMS		
960	22	06411055010	5	5	1422410	1630680	1994020	2132800	2263680	NO SUSPENDED ITEMS		

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
961	22	06411055010	4	4	656600	789400	1214920	1482630		NO SUSPENDED ITEMS
962	22	06411055010	3	3	1364040	1913280	2786490			NO SUSPENDED ITEMS
963	22	06411055010	4	4	592530	964250	1210360	2988650		NO SUSPENDED ITEMS
964	22	06411055010	4	4	1615230	2014510	2838655	3849310		NO SUSPENDED ITEMS
965	22	06411055010	5	5	1014730	1136020	1218810	2028330	2271630	NO SUSPENDED ITEMS
966	22	06411055010	4	4	1677290	1831830	2147420	2822060		NO SUSPENDED ITEMS
967	22	06411055010	4	4	1701580	1922390	2538730	3214280		NO SUSPENDED ITEMS
968	22	06411055010	4	4	1471360	1674460	2511580	2696790		NO SUSPENDED ITEMS
969	22	06411055010	4	4	1289480	2215280	2275400	2684050		NO SUSPENDED ITEMS
970	22	06411055010	4	4	552240	925150	1083980	1722320		NO SUSPENDED ITEMS
971	22	06411055010	4	4	792160	1238870	1858730	2715180		NO SUSPENDED ITEMS
972	22	06411055010	4	4	1223430	1982970	2031220	3021420		NO SUSPENDED ITEMS
973	22	03211055010	3	3	1019780	1072670	1313100			NO SUSPENDED ITEMS
974	22	03211055010	4	4	1309440	1321730	1374520	1403060		NO SUSPENDED ITEMS
975	22	03211055010	4	4	1130350	1341870	1748320	2029090		NO SUSPENDED ITEMS
976	22	06411055010	4	4	647240	850155	1922180	2757270		NO SUSPENDED ITEMS
977	22	06411055010	4	4	1480430	1719880	2239280	2270570		NO SUSPENDED ITEMS
978	22	06411055010	4	4	919450	1603860	1800850	2024170		NO SUSPENDED ITEMS
979	22	06411055010	4	4	968990	1549380	2371140	2606560		NO SUSPENDED ITEMS
980	22	06411055010	4	4	1124040	1265490	1471740	1488100		NO SUSPENDED ITEMS
981	22	06411055010	4	4	939160	951900	1004430	1251210		NO SUSPENDED ITEMS
982	22	06411055010	4	4	987700	1200120	1248660	1458350		NO SUSPENDED ITEMS
983	22	06411055010	4	4	946550	957260	1049110	1236500		NO SUSPENDED ITEMS
984	22	06411055010	4	4	1041980	1049020	1150030	1173590		NO SUSPENDED ITEMS
985	22	06411055010	4	4	950080	1048270	1049650	1168500		NO SUSPENDED ITEMS
986	22	06411055010	3	3	305250	1600710	3260950			NO SUSPENDED ITEMS
987	22	06411055010	4	4	200810	842700	1177760	1494150		NO SUSPENDED ITEMS
1000	5	03111021010	3	3	1780	2310	3250			NO SUSPENDED ITEMS
1001	5	03111021010	4	4	6600	11100	13800	15600		NO SUSPENDED ITEMS
1002	5	03111021010	5	5	21300	23600	25000	25100	24300	NO SUSPENDED ITEMS
1003	5	03111021010	4	4	33700	37100	40500	47500		NO SUSPENDED ITEMS
1004	5	03111021010	3	3	197800	213400	231600			NO SUSPENDED ITEMS
1005	5	03111021010	3	3	17100	21300	24600			NO SUSPENDED ITEMS
1006	5	03111021010	3	3	48900	50600	70100			NO SUSPENDED ITEMS
1007	5	03111021010	5	5	217600	217700	277800	307200	471400	NO SUSPENDED ITEMS
1008	5	03111021010	3	3	11900	16100	17800			NO SUSPENDED ITEMS
1009	5	03111021010	3	3	8041	8705	9234			NO SUSPENDED ITEMS
1010	5	03111021010	3	3	60100	61600	67400			NO SUSPENDED ITEMS
1011	5	03111021010	3	3	313200	337300	715500			NO SUSPENDED ITEMS
1012	6	03911028010	2	2	37000	37000				NO SUSPENDED ITEMS

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
1013	6	03911028010	2	2	704000	762000				NO SUSPENDED ITEMS
1014	6	03911028010	2	2	4000	5000				NO SUSPENDED ITEMS
1015	6	03911028010	2	2	953000	998000				NO SUSPENDED ITEMS
1016	6	03911028010	3	3	10000	14000	19000			NO SUSPENDED ITEMS
1017	6	03911028010	3	3	78000	310000	332000			NO SUSPENDED ITEMS
1018	6	03911021010	3	3	43000	43000	56000			NO SUSPENDED ITEMS
1019	6	03911021010	3	3	108000	118000	131000			NO SUSPENDED ITEMS
1020	6	03911021010	3	3	37000	40000	58000			NO SUSPENDED ITEMS
1021	6	03911021010	3	3	98000	118000	130000			NO SUSPENDED ITEMS
1022	6	03911021010	3	3	166000	181000	206000			NO SUSPENDED ITEMS
1023	6	03911021010	3	3	285000	364000	474000			NO SUSPENDED ITEMS
1024	6	03911021010	3	3	420000	438000	446000			NO SUSPENDED ITEMS
1025	6	03911021010	7	7	37000	40000	43000	43000	56000	NO SUSPENDED ITEMS
					56000	58000				
1026	6	03911021010	7	7	89000	98000	108000	118000	119000	NO SUSPENDED ITEMS
					130000	131000				
1027	6	03911021010	3	3	166000	181000	206000			NO SUSPENDED ITEMS
1028	6	03911021010	7	7	199000	285000	364000	420000	438000	NO SUSPENDED ITEMS
					446000	474000				
1029	7	03111021010	3	3	36700	47200	49700			NO SUSPENDED ITEMS
1030	7	03111021010	3	3	42400	80300	90200			NO SUSPENDED ITEMS
1031	7	03111021010	5	5	137200	142700	159300	158400	222800	NO SUSPENDED ITEMS
1032	7	03111021010	3	3	306100	449400	798400			NO SUSPENDED ITEMS
1033	7	03111021010	3	3	726600	963700	976600			NO SUSPENDED ITEMS
1034	7	03111021010	3	3	96500	114100	202500			NO SUSPENDED ITEMS
1035	7	03111021010	3	3	91900	112100	129800			NO SUSPENDED ITEMS
1036	7	03111021010	3	3	324900	378900	415300			NO SUSPENDED ITEMS
1037	7	03111021010	3	3	473000	576000	796600			NO SUSPENDED ITEMS
1038	7	03111021010	3	2	930400	982700				786400
1039	7	03111021010	3	3	19700	19700	34500			NO SUSPENDED ITEMS
1040	7	03111021010	3	3	19500	59900	79800			NO SUSPENDED ITEMS
1041	7	03111021010	3	3	69700	208200	466700			NO SUSPENDED ITEMS
1042	7	03111021010	3	3	409300	513600	1148000			NO SUSPENDED ITEMS
1043	7	0311021010*	3	2	354000	1139900				705700
1044	7	03111021010	2	2	28200	46000				NO SUSPENDED ITEMS
1045	7	03111021010	3	3	77100	120100	142900			NO SUSPENDED ITEMS
1046	7	03111021010	3	3	139200	242300	269200			NO SUSPENDED ITEMS
1047	7	03111021010	3	3	386600	498300	564900			NO SUSPENDED ITEMS
1048	7	03111021010	3	3	21400	28400	33900			NO SUSPENDED ITEMS
1049	7	03111021010	2	2	76100	91400				NO SUSPENDED ITEMS

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION	
1050	7	03111021010	4	3	224400	225400	479600			195400	
1052	7	03111021010	11	11	39500	58900	76100	77100	79800	NO SUSPENDED ITEMS	
					91400	96500	114100	120100	162900		
					202500						
1053	7	03111021010	8	8	18700	19700	21400	28200	28400	NO SUSPENDED ITEMS	
					33900	34500	46000				
1054	7	03111021010	13	12	68700	188200	208200	224400	225400	195400	
					242300	269200	324900	378900	415300		
					466700	479600					
1055	7	03111021012	6	6	409300	473000	513600	576000	796600	NO SUSPENDED ITEMS	
					1148000						
1056	7	03111021010	6	4	830400	882700	954000	1139900		705700	786400
1057	8	08211028010	4	4	24000	28000	68000	70000		NO SUSPENDED ITEMS	
1058	8	08211028010	4	4	57000	93000	206000	312000		NO SUSPENDED ITEMS	
1059	8	08211028010	4	2	206000	312000				57000	93000
1060	8	08211028010	4	2	57000	93000				206000	312000
1061	8	08211028010	4	4	4000	4000	4000	5000		NO SUSPENDED ITEMS	
1062	8	08211028010	4	4	10000	10000	13000	17000		NO SUSPENDED ITEMS	
1063	8	08211028010	4	4	54000	79000	84000	174000		NO SUSPENDED ITEMS	
1064	8	08211028010	4	4	411000	493000	811000	1020000		NO SUSPENDED ITEMS	
1065	8	08211028010	4	2	493000	811000				411000	1020000
1066	8	08211028010	4	2	411000	1020000				493000	811000
1067	8	08211028010	4	4	6000	9000	10000	11000		NO SUSPENDED ITEMS	
1068	8	08211028010	4	4	14000	15000	17000	21000		NO SUSPENDED ITEMS	
1069	8	08211028010	4	4	104000	117000	119000	141000		NO SUSPENDED ITEMS	
1070	8	08211028010	4	4	244000	267000	299000	477000		NO SUSPENDED ITEMS	
1072	8	08211028010	4	4	786000	833000	860000	1077000		NO SUSPENDED ITEMS	
1073	8	05011028010	4	4	4000	8000	8000	8500		NO SUSPENDED ITEMS	
1074	8	05011028010	4	4	23000	44000	72000	108000		NO SUSPENDED ITEMS	
1075	8	05011028010	4	4	185000	452000	716000	1131000		NO SUSPENDED ITEMS	
1080	8	05011028010	4	4	3000	5000	14000	14500		NO SUSPENDED ITEMS	
1081	8	05011028010	4	4	13000	15000	32000	85000		NO SUSPENDED ITEMS	
1082	8	05011028010	4	4	128000	366000	461000	622000		NO SUSPENDED ITEMS	
1083	8	05011028010	4	4	4500	5500	5500	9000		NO SUSPENDED ITEMS	
1084	8	05011028010	4	4	11000	14000	22000	32000		NO SUSPENDED ITEMS	
1085	8	05011028010	4	4	72000	128000	155000	166000		NO SUSPENDED ITEMS	
1086	8	03411028010	4	4	1500	2000	2000	15500		NO SUSPENDED ITEMS	
1087	8	03411028010	4	4	13000	40000	92000	135000		NO SUSPENDED ITEMS	
1088	8	03411028010	4	4	164000	265000	290000	367000		NO SUSPENDED ITEMS	
1089	8	03411028010	3	3	3500	5000	5500			NO SUSPENDED ITEMS	

LISTED NUMBERS OF CYCLES TO FAILURE AND CYCLES TO SUSPENSION OF TESTING WITHOUT FAILURE FOR ALL GROUPS IN THE DATA COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
1090	9	03411028010	4	4	15000	17000	18000	46000		NO SUSPENDED ITEMS
1091	4	03411028010	4	4	88000	194300	396000	422000		NO SUSPENDED ITEMS
1092	8	03411028010	4	4	511000	667000	1107000	2169000		NO SUSPENDED ITEMS
1093	7	03111321010	7	6	369400	384600	386700	488300	564900	674700
					1289500					
1094	41	06411921010	3	3	7000	11000	15000			NO SUSPENDED ITEMS
1095	41	06411821010	3	3	22000	24000	24000			NO SUSPENDED ITEMS
1096	41	06411421010	3	3	36000	38000	46000			NO SUSPENDED ITEMS
1097	41	06411821010	3	3	69000	76000	79000			NO SUSPENDED ITEMS
1098	44	15610821010	2	2	42000	43000				NO SUSPENDED ITEMS
1099	44	15610821010	2	2	494000	574000				NO SUSPENDED ITEMS
1100	47	06311821010	8	8	57900	62300	77000	92300	110100	NO SUSPENDED ITEMS
					113200	128900	136000			
1101	47	05611821210	7	7	48400	52100	56300	62300	72600	NO SUSPENDED ITEMS
					77200	80000				
1102	20	03211321010	10	10	101000	104000	110000	115000	134000	NO SUSPENDED ITEMS
					139000	142000	145000	165000	175000	
1103	20	03211021010	10	10	145000	187000	225000	248000	260000	NO SUSPENDED ITEMS
					281000	283000	284000	286000	382000	
1104	20	03211021010	10	10	400000	400000	498000	566000	640000	NO SUSPENDED ITEMS
					663000	675000	706000	759000	1236000	
1105	72	00010806010	4	4	7000	9000	10000	12000		NO SUSPENDED ITEMS
1106	72	00010906010	4	4	37000	37000	42000	63000		NO SUSPENDED ITEMS
1107	72	00010806010	4	4	452000	506000	514000	687000		NO SUSPENDED ITEMS
1108	72	00010806010	4	4	4000	4000	6000	7000		NO SUSPENDED ITEMS
1109	72	00010906010	5	5	3000	5000	6000	13000	15000	NO SUSPENDED ITEMS
1110	72	00010806010	3	3	42000	48000	49000			NO SUSPENDED ITEMS
1111	72	00010806010	4	4	196000	199000	202000	204000		NO SUSPENDED ITEMS
1112	72	00010806010	4	4	289000	377000	469000	618000		NO SUSPENDED ITEMS
1113	72	00010906010	5	5	4000	4000	6000	7000	8000	NO SUSPENDED ITEMS
1114	72	00010806010	4	4	4000	6000	13000	15000		NO SUSPENDED ITEMS
1115	72	00010806010	3	3	8000	10000	11000			NO SUSPENDED ITEMS
1116	72	00010806010	3	3	27000	43000	51000			NO SUSPENDED ITEMS
1117	72	00010806010	4	4	51000	58000	68000	91000		NO SUSPENDED ITEMS
1118	72	00010806010	4	4	121000	135000	138000	253000		NO SUSPENDED ITEMS
1119	72	00010806010	5	5	10000	15000	21000	26000	30000	NO SUSPENDED ITEMS
1120	72	00010806010	5	5	10000	12000	18000	19000	27000	NO SUSPENDED ITEMS
1121	72	00010806010	4	4	185000	196000	201000	273000		NO SUSPENDED ITEMS
1122	72	00010806010	4	4	9000	10000	10000	13000		NO SUSPENDED ITEMS
1123	72	00010806010	4	4	23000	28000	29000	30000		NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
1124	72	00010806010	4	4	47000	64000	66000	534000		NO SUSPENDED ITEMS
1125	72	00010806010	5	5	139000	183000	311000	404000	411000	NO SUSPENDED ITEMS
1126	72	00010806010	4	4	6000	7000	7000	9000		NO SUSPENDED ITEMS
1127	72	00010806010	3	3	16000	16000	18000			NO SUSPENDED ITEMS
1128	72	00010806010	4	4	37000	60000	72000	81000		NO SUSPENDED ITEMS
1129	72	00010806010	3	3	107000	108000	152000			NO SUSPENDED ITEMS
1130	72	00010806010	4	4	7000	7000	8000	8000		NO SUSPENDED ITEMS
1131	72	00010806010	4	4	12000	13300	14000	15000		NO SUSPENDED ITEMS
1132	72	00010806010	4	4	23000	39000	41000	58000		NO SUSPENDED ITEMS
1133	72	00010806010	2	2	151000	164000				NO SUSPENDED ITEMS
1134	72	00010806010	4	4	373000	388000	579000	814000		NO SUSPENDED ITEMS
1135	72	00010806010	4	4	5000	7000	7000	8000		NO SUSPENDED ITEMS
1136	72	00010806010	4	4	11000	13000	22000	24000		NO SUSPENDED ITEMS
1137	72	00010806010	4	4	63000	69000	135000	248000		NO SUSPENDED ITEMS
1138	72	00010806010	3	3	60000	90000	279000			NO SUSPENDED ITEMS
1139	72	00010806010	6	4	189000	196000	507000	707000		2490000 2522000
1180	8	08211028010	2	2	831	934				NO SUSPENDED ITEMS
1181	8	08211028010	4	4	1173	1736	1770	2000		NO SUSPENDED ITEMS
1182	8	08211028010	2	2	29	101				NO SUSPENDED ITEMS
1183	8	08211028010	3	3	257	302	383			NO SUSPENDED ITEMS
1184	8	05011028010	4	4	14	56	137	184		NO SUSPENDED ITEMS
1185	8	05011028010	4	4	106	283	291	637		NO SUSPENDED ITEMS
1186	8	05011028010	2	2	116	497				NO SUSPENDED ITEMS
1187	8	05011028010	4	4	63	69	113	188		NO SUSPENDED ITEMS
1188	8	05011028010	4	4	121	230	233	286		NO SUSPENDED ITEMS
1189	8	03411028010	3	3	51	458	769			NO SUSPENDED ITEMS
1190	8	03411028010	3	3	34	66	96			NO SUSPENDED ITEMS
1191	8	03411028010	3	3	262	350	835			NO SUSPENDED ITEMS
1192	72	00010806010	2	2	500	635				NO SUSPENDED ITEMS
1193	72	00010806010	4	4	1278	1320	1511	1546		NO SUSPENDED ITEMS
1194	72	00010806010	6	6	1732	1752	1807	1816	2006	NO SUSPENDED ITEMS
					2529					
1195	72	00010806010	6	6	2735	3520	3680	4373	5000	NO SUSPENDED ITEMS
1196	72	00010806010	3	3	7	42	52			NO SUSPENDED ITEMS
1197	72	00010806010	4	4	574	625	698	759		NO SUSPENDED ITEMS
1198	72	00010806010	4	4	1170	1230	1440	1591		NO SUSPENDED ITEMS
1199	72	00010806010	4	4	21	47	3301	4119		NO SUSPENDED ITEMS
1200	72	00010806010	10	10	30	35	120	138	450	NO SUSPENDED ITEMS
					3210	3318	3459	3512	4135	
1201	72	00010806010	4	4	4338	4719	5520	6017		NO SUSPENDED ITEMS

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION		
1202	72	00010806010	3	3	5	85	471			NO SUSPENDED ITEMS		
1203	72	00010806010	4	4	63	2298	2755	4100		NO SUSPENDED ITEMS		
1204	72	00010906010	4	4	2945	3064	3248	4161		NO SUSPENDED ITEMS		
1240	5	03111021010	[illegible]	2	838600	1305000				8164000		
1241	5	03111021010	5	5	1164200	1597300	2359000	5771100	7219000	NO SUSPENDED ITEMS		
1242	5	03111021010	2	2	6561000	8640000				NO SUSPENDED ITEMS		
1243	5	03111021010	6	6	566600	1372800	1500800	1594000	3484500	NO SUSPENDED ITEMS		
					17040000							
1244	5	03111021010	3	3	1970400	4816100	16245200			NO SUSPENDED ITEMS		
1245	5	03111021010	3	3	3821400	5608500	10403200			NO SUSPENDED ITEMS		
1246	6	03911028010	3	2	2208000	4099000				20677000		
1247	6	03911028010	2	2	2284000	4640000				NO SUSPENDED ITEMS		
1249	6	03911021010	3	3	1046000	1162000	1838000			NO SUSPENDED ITEMS		
1250	6	03911021010	3	3	759300	1474000	1674000			NO SUSPENDED ITEMS		
1251	6	03911021010	7	7	162000	759000	1046300	1194000	1474000	NO SUSPENDED ITEMS		
					1674000	1838000						
1252	6	03911021010	3	3	2051000	6000000	13138000			NO SUSPENDED ITEMS		
1253	7	03111021010	3	3	1547500	2136200	3012700			NO SUSPENDED ITEMS		
1254	7	03111021010	3	2	2219500	3222300				21000000		
1255	7	03111021010	3	2	6167100	7151600				20000000		
1256	7	03111021010	3	2	4055100	6692700				20000000		
1257	7	03111021010	4	4	984100	957900	1113000	1206600		NO SUSPENDED ITEMS		
1258	7	03111021010	4	4	1306300	1425200	1516000	1655300		NO SUSPENDED ITEMS		
[illegible]	7	0311102101	4	2	1147100	1549700				735800	20000000	
[illegible]	7	03111021010	4	4	4055100	6167100	6692700	7151600		20000000	20000000	20000000
										20000000		
[illegible]	8	[illegible]	4	3	954000	1218000	1493000			45283000		
[illegible]	8	[illegible]	4	3	1161000	1301000	1368000			25427000		
[illegible]	8	[illegible]	4	2	10476000	26373000				10949000	33542000	
[illegible]	8	[illegible]	4	4	1298000	1521000	1673000	1701000		NO SUSPENDED ITEMS		
[illegible]	8	09211028010	4	2	4926000	12200000				10373000	51944000	
[illegible]	8	09011028010	4	3	1403000	4754000	11202000			10000000		
[illegible]	8	09011028010	4	[illegible]	534000	1232000	6817000			8743000		
[illegible]	8	[illegible]	4	2	6806000	9595000				22121000	49821000	
[illegible]	8	[illegible]	4	4	606000	1433000	1919000	3226000		NO SUSPENDED ITEMS		
1271	[illegible]	[illegible]	4	2	4101000	29110000				22671000	34021000	
[illegible]	8	03611028010	4	4	523000	591000	1711000	2365000		NO SUSPENDED ITEMS		
[illegible]	8	[illegible]	4	4	1549000	2164000	11297000	4952?000		NO SUSPENDED ITEMS		
[illegible]	[illegible]	[illegible]	4	[illegible]	4474000	8944000				41862000	70000000	

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
1277	7	03111021010	8	6	884100	957900	1113000	1187100	1206600	735800 20000000
					1540700					
1278	42	06411821010	3	3	1720000	2558000	4203000			NO SUSPENDED ITEMS
1279	20	03211021010	10	10	259000	1197000	1218000	1658000	1868000	NO SUSPENDED ITEMS
					1989000	2038000	2455000	2847000	16533000	
1300	20	03211021010	7	7	643000	744000	768000	773000	810000	NO SUSPENDED ITEMS
					930000	972000				
1301	20	03211021010	7	7	488000	706000	796000	815000	840000	NO SUSPENDED ITEMS
					1448000	1467000				
1302	20	03211021010	7	7	453000	489000	651000	708000	722000	NO SUSPENDED ITEMS
					808000	814000				
1303	20	03211021010	7	7	444000	444000	483000	489000	562000	NO SUSPENDED ITEMS
					569000	583000				
1304	20	03211021010	7	7	406000	643000	652000	699000	747000	NO SUSPENDED ITEMS
					815000	978000				
1305	20	03211021010	7	7	515000	633000	816000	842000	842000	NO SUSPENDED ITEMS
					894000	941000				
1306	20	03211021010	7	7	532000	614000	696000	697000	788000	NO SUSPENDED ITEMS
					900000	941000				
1307	20	03211021010	7	7	560000	572000	674000	735000	775000	NO SUSPENDED ITEMS
					776000	923000				
1308	20	03211021010	4	4	487000	627000	830000	930000		NO SUSPENDED ITEMS
1540	20	03211021010	7	7	656000	955000	982000	984000	1073000	NO SUSPENDED ITEMS
					1148000	1283000				
1541	20	03211021010	7	7	1084000	1261000	1261000	1295000	1295000	NO SUSPENDED ITEMS
					1302000	1825000				
1542	20	03211021010	3	3	7734000	10769000	12225000			NO SUSPENDED ITEMS
1543	20	03211021010	4	4	4556000	4556000	4776000	5625000		NO SUSPENDED ITEMS
1544	20	03211021010	5	5	163000	1214000	3228000	8722000	9537000	NO SUSPENDED ITEMS
1545	20	03211021010	7	7	1923000	2355000	2364000	2608000	3565000	NO SUSPENDED ITEMS
					4155000	4229000				
1546	20	03211021010	7	7	734000	744000	806000	887000	1083000	NO SUSPENDED ITEMS
					1107000	1300000				
1547	20	03211021010	7	7	1132000	1142000	1294000	1784000	1956000	NO SUSPENDED ITEMS
					2118000	2120000				
1548	20	03211021010	7	7	1549000	1819000	1953000	2201000	2604000	NO SUSPENDED ITEMS
					2632000	3250000				
1549	20	03211021010	7	7	1141000	1630000	1793000	1793000	2617000	NO SUSPENDED ITEMS
					4972000	10432000				
2300	31	00054083011	3	3	36300	49700	68300			NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND CYCLES TO SUSPENSION OF TESTING WITHOUT FAILURE FOR ALL GROUPS IN THE DATA COLLECTION

ITEM NO.	DESCRIPTION		SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
2301	41	00056083011	3	3	973600	895400	1309500			NO SUSPENDED ITEMS
2302	41	00050083011	2	2	16960	30000				NO SUSPENDED ITEMS
2303	41	00053083011	2	2	30000	35000				NO SUSPENDED ITEMS
2304	41	00050083011	2	2	250000	400000				NO SUSPENDED ITEMS
2305	41	00056083011	2	2	11832	13356				NO SUSPENDED ITEMS
2306	41	00056083011	3	3	52634	108676	161506			NO SUSPENDED ITEMS
2307	41	00055083011	3	3	359000	369900	650000			NO SUSPENDED ITEMS
2308	41	00055083011	3	3	11000	12000	17000			NO SUSPENDED ITEMS
2309	41	00055083011	3	3	479600	1115200	1634700			NO SUSPENDED ITEMS
2310	42	00055081011	2	2	59400	97000				NO SUSPENDED ITEMS
2311	42	00055081011	2	2	9000	11700				NO SUSPENDED ITEMS
2312	42	00055081011	3	3	8600	20500	31200			NO SUSPENDED ITEMS
2313	42	00055093011	2	2	32000	39900				NO SUSPENDED ITEMS
2314	42	00051081011	2	2	361000	398000				NO SUSPENDED ITEMS
2315	42	00051081011	2	2	672600	1438400				NO SUSPENDED ITEMS
2316	42	00055081011	2	2	34500	4060				NO SUSPENDED ITEMS
2317	39	05111081100	3	3	202000	22900	270000			NO SUSPENDED ITEMS
2318	64	00011081021	2	2	15144	16413				NO SUSPENDED ITEMS
2319	64	00011081021	2	2	3405	4160				NO SUSPENDED ITEMS
2320	64	00011081021	2	2	13000	16000				NO SUSPENDED ITEMS
2321	64	00011081021	2	2	13861	20377				NO SUSPENDED ITEMS
2322	64	00011081021	2	2	6496	81 8				NO SUSPENDED ITEMS
2323	64	00011181021	2	2	7118	84 3				NO SUSPENDED ITEMS
2324	64	00011081021	2	2	14011	150 9				NO SUSPENDED ITEMS
2325	1	00012883072	2	2	379939	976035				NO SUSPENDED ITEMS
2326	1	00012883072	3	3	783401	911633	928001			NO SUSPENDED ITEMS
2327	1	00012483072	3	3	297948	421764	473989			NO SUSPENDED ITEMS
2328	1	00012883072	2	2	638744	757582				NO SUSPENDED ITEMS
2329	1	00012883072	2	2	218891	396309				NO SUSPENDED ITEMS
2330	68	00056081021	6	6	215000	255000	360000	545000	580000	NO SUSPENDED ITEMS
					745000					
2331	68	00056081021	6	6	210000	225000	550000	572000	574000	NO SUSPENDED ITEMS
					772000					
2332	68	00056081021	4		155000	205000	205000	240000		NO SUSPENDED ITEMS
2333	68	00056081021	3		138000	155000	160000			NO SUSPENDED ITEMS
2334	68	00056081021	2	2	255000	515000				NO SUSPENDED ITEMS
2335	68	00056081021	2	2	425000	430000				NO SUSPENDED ITEMS
2336	69	00056081021	2	2	470000	480000				NO SUSPENDED ITEMS
2337	69	00056081021	6	6	138000	143000	155000	160000	200000	NO SUSPENDED ITEMS
					545000					

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[illegible]	[illegible]	[illegible]	[illegible]	CYCLES AT FAILURE					CYCLES AT SUSPENSION
[illegible]	[illegible]	[illegible]	[illegible]	5000	5500	11300	11900	14400	NO SUSPENDED ITEMS
				18000					
[illegible]	[illegible]	[illegible]	[illegible]	11000	11000	14400	17000	[illegible]	NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	11300	19000	27000			NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	26000	30400	35500	39600	49600	NO SUSPENDED ITEMS
				51000					
[illegible]	[illegible]	[illegible]	[illegible]	5000	5500	18000	33000	37200	NO SUSPENDED ITEMS
				51000					
[illegible]	[illegible]	[illegible]	[illegible]	50000	51000	56000	63000	70000	NO SUSPENDED ITEMS
				73000					
[illegible]	[illegible]	4	4	65000	86500	91000	95800		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	44000	46000	55400	90500		NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	40000	82000				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	51500	54000				NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	1536	2146	2345	2409		NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	4656	5826				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	24288	29558				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	147437	152007				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	38569	40368	52170			NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	44765	45963	51299			NO SUSPENDED ITEMS
[illegible]	[illegible]	2	2	77291	92332				NO SUSPENDED ITEMS
[illegible]	[illegible]	2	[illegible]	37575	59338				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	1192	1200	1700			NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	1000	1000	2000			NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	3860	6610	7190			NO SUSPENDED ITEMS
[illegible]	[illegible]	2	2	1861	1473				NO SUSPENDED ITEMS
[illegible]	[illegible]	2	[illegible]	619	900				NO SUSPENDED ITEMS
[illegible]	[illegible]	2	2	1403400	1494600				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	20782	26025	29065			NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	620400	632000	1982000			NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	25600	35400	42500			NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	23140	29640	40680			NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	40000	42500	47700			NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	116000	121200	144600			NO SUSPENDED ITEMS
[illegible]	[illegible]	2	2	530	679				NO SUSPENDED ITEMS
[illegible]	[illegible]	2	2	468	634				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	9250	9710	9790			NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	1280	2080				NO SUSPENDED ITEMS
[illegible]	[illegible]	2	[illegible]	1228	1560				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	908600	1014000	2585000			NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND CYCLES TO SUSPENSION OF TESTING WITHOUT FAILURE FOR ALL GROUPS IN THE DATA COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15400	26000	44900			NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13000	14500				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15300	17200				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	790000	1070000				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7500	14700	19600	23300	28100	NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15900	21100				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	22500	23500				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11200	17300	32100			NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9000	9000	9700			NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9000	9000	9700			NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	32800	33300	59400	60400	74900	NO SUSPENDED ITEMS
					131100					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	32800	34600	59800	74700	80900	NO SUSPENDED ITEMS
					131100					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	40100	59600	155100	162500		NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	40100	60000	163200	164000		NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30600	31400				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30400	33000				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21600	55200	93600	176100		NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24800	55800	93600	176100		NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20400	21200				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21800	22200				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20000	26200	27700	41200		NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26100	26600	27700	41200		NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28800	45700	67300	74500		NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	48240	62600	67300	74500		NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	32700	124500				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	32700	126100				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	50800	51200				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	50800	52300				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21200	24800				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21200	24800				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	43200	63000				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	43200	63000				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13900	18700	20200	21600	25400	NO SUSPENDED ITEMS
					52500					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13900	18200	20200	21600	25400	NO SUSPENDED ITEMS
					52800					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18400	42000				NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18400	42000				NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
2745	36	10211922011	5	5	20000	20400	32100	33600	34300	NO SUSPENDED ITEMS
2746	36	10211822010	5	5	20400	21200	33200	33600	34300	NO SUSPENDED ITEMS
2747	36	10211811011	4	4	24900	27300	38200	70000		NO SUSPENDED ITEMS
2748	36	10211811010	4	4	24900	27300	38200	70000		NO SUSPENDED ITEMS
2749	36	10211811011	4	4	61400	66700	130500	196800		NO SUSPENDED ITEMS
2750	36	10211811010	4	4	61400	66700	130500	196800		NO SUSPENDED ITEMS
2751	36	10211811011	3	3	46500	81000	94000			NO SUSPENDED ITEMS
2752	36	10211811010	3	3	46500	81100	94000			NO SUSPENDED ITEMS
2753	37	04011083010	4	4	4000	7000	7500	9000		NO SUSPENDED ITEMS
2754	37	04011083010	4	4	21000	34000	41000	43000		NO SUSPENDED ITEMS
2755	37	04011083010	5	4	21000	25000	50000	56000		65000
2756	37	04011081010	3	2	40000	76000				70000
2757	37	04011083010	4	4	10000	12000	13000	14000		NO SUSPENDED ITEMS
2758	37	04011083010	4	4	30000	37000	47000	48000		NO SUSPENDED ITEMS
2759	37	03211081010	3	3	9600	9600	13200			NO SUSPENDED ITEMS
2760	37	03211081010	4	4	12000	13800	14400	16200		NO SUSPENDED ITEMS
2761	37	03211081010	7	7	9600	9600	12000	13200	13800	NO SUSPENDED ITEMS
					14400	16200				
2762	37	06411083010	4	4	5000	5000	5000	7000		NO SUSPENDED ITEMS
2763	37	06411083090	3	3	19000	22000	26000			NO SUSPENDED ITEMS
2790	37	04011083010	2	2	900	1100				NO SUSPENDED ITEMS
2821	32	00055081011	2	2	878000	1674000				NO SUSPENDED ITEMS
2822	32	00055081010	2	2	1218000	1867000				NO SUSPENDED ITEMS
2823	32	00055084010	2	2	1793000	1895000				NO SUSPENDED ITEMS
2825	36	06411912011	3	3	1755400	2001000	2067000			NO SUSPENDED ITEMS
2826	36	06411812010	3	3	1755400	2001000	2067000			NO SUSPENDED ITEMS
2850	32	00012083011	2	2	30000	35000				NO SUSPENDED ITEMS
2851	32	00010083010	2	2	65000	309900				NO SUSPENDED ITEMS
2852	32	00010083010	2	2	32400	48400				NO SUSPENDED ITEMS
2853	69	00056091020	6	6	1352	1370	1371	1382	1431	NO SUSPENDED ITEMS
					2252					
2854	69	00056091021	6	6	1343	1362	1363	1378	1398	NO SUSPENDED ITEMS
					2246					
2855	69	00056081020	4	4	3316	3811	4077	4180		NO SUSPENDED ITEMS
2856	69	00056081021	4	4	3146	3679	4020	4072		NC SUSPENDED ITEMS
2857	69	0005[illegible]081020	4	4	8566	9569	10611	11546		NC SUSPENDED ITEMS
2858	69	00056091021	4	4	7797	9270	9500	11352		NO SUSPENDED ITEMS
2859	69	00056091020	6	6	36135	36295	36307	40136	72805	NO SUSPENDED ITEMS
					113973					

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ITEM	[illegible]	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
2860	69	00056081021	6	6	35110	36106	36145	38351	69616	NO SUSPENDED ITEMS
					107500					
2861	69	00055081020	2	2	2863	5892				NO SUSPENDED ITEMS
2862	69	00012081021	2	2	2856	5850				NO SUSPENDED ITEMS
2863	69	00056081020	2	2	8877	12731				NO SUSPENDED ITEMS
2864	69	00012191021	2	2	9067	12526				NO SUSPENDED ITEMS
2865	69	00011081021	2	2	8468	12260				NO SUSPENDED ITEMS
2866	69	00055081020	2	2	25456	35716				NO SUSPENDED ITEMS
2867	69	00012081021	2	2	20000	32599				NO SUSPENDED ITEMS
2868	69	00011081021	2	2	21000	22805				NO SUSPENDED ITEMS
2869	69	00055081020	2	2	110940	193494				NO SUSPENDED ITEMS
2870	69	00012091021	2	2	101000	181721				NO SUSPENDED ITEMS
2871	69	00011091021	2	2	77000	130358				NO SUSPENDED ITEMS
2872	69	00056091020	2	2	976	1387				NO SUSPENDED ITEMS
2873	69	00012081021	2	2	949	1271				NO SUSPENDED ITEMS
2874	69	00011081021	2	2	949	1271				NO SUSPENDED ITEMS
2875	69	00056081020	2	2	9509	17800				NO SUSPENDED ITEMS
2876	69	00012081021	2	2	7500	15850				NO SUSPENDED ITEMS
2877	69	00011091021	2	2	7500	16088				NO SUSPENDED ITEMS
2878	69	00056081020	2	2	30000	79160				NO SUSPENDED ITEMS
2879	69	00012081021	2	2	21925	66999				NO SUSPENDED ITEMS
2880	69	00011081021	2	2	21925	77500				NO SUSPENDED ITEMS
2881	69	00056081020	2	2	103218	116427				NO SUSPENDED ITEMS
2882	69	00012081021	2	2	95837	109000				NO SUSPENDED ITEMS
2883	69	00011091021	2	2	55600	88000				NO SUSPENDED ITEMS
2884	69	00056081020	2	2	1377	1901				NO SUSPENDED ITEMS
2885	69	00012091021	2	2	648	1836				NO SUSPENDED ITEMS
2886	69	00011081021	2	2	897	1836				NO SUSPENDED ITEMS
2887	69	00056081020	2	2	8993	12120				NO SUSPENDED ITEMS
2888	69	00012091021	2	2	8571	11388				NO SUSPENDED ITEMS
2889	69	00011091021	2	2	7564	11999				NO SUSPENDED ITEMS
2890	69	00056081020	2	2	43618	46427				NO SUSPENDED ITEMS
2891	69	00012081021	2	2	36416	43406				NO SUSPENDED ITEMS
2892	69	00011081021	2	2	36800	44000				NO SUSPENDED ITEMS
2893	69	00056081070	3	3	22682	33992	38629			NO SUSPENDED ITEMS
2894	69	00056081071	2	2	29555	38293				NO SUSPENDED ITEMS
2895	69	00056081070	3	3	67309	93770	113209			NO SUSPENDED ITEMS
2896	69	00056081071	2	2	66770	93231				NO SUSPENDED ITEMS
2897	69	00056081070	3	3	74536	107560	109572			NO SUSPENDED ITEMS
2898	69	00056081071	2	2	46975	80331				NO SUSPENDED ITEMS

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
2899	69	00056081070	3	3	35256	45459	50883			NO SUSPENDED ITEMS
2900	69	00056091071	2	2	34719	50882				NO SUSPENDED ITEMS
2901	69	00056081070	3	3	31680	37020	40160			NO SUSPENDED ITEMS
2902	69	00056091070	3	3	55019	64833	68430			NO SUSPENDED ITEMS
2903	69	00056081071	2	2	39065	65002				NO SUSPENDED ITEMS
2940	69	00056081020	2	2	159	249				NO SUSPENDED ITEMS
2941	69	00056081020	2	2	313	551				NO SUSPENDED ITEMS
2942	69	00056091020	2	2	659	764				NO SUSPENDED ITEMS
2943	69	00012081021	2	2	637	690				NO SUSPENDED ITEMS
2944	69	00011081021	2	2	659	750				NO SUSPENDED ITEMS
2971	32	00010083010	3	3	629100	1829000	1873000			NO SUSPENDED ITEMS
3000	13	09001865010	6	6	30000	39000	40000	49000	52000	NO SUSPENDED ITEMS
					53000					
3001	16	09001865010	2	2	3400	3500				NO SUSPENDED ITEMS
3002	16	09001865010	2	2	6500	7700				NO SUSPENDED ITEMS
3003	16	09001865010	2	2	710000	754000				NO SUSPENDED ITEMS
3004	16	09001860010	2	2	16500	17100				NO SUSPENDED ITEMS
3005	16	09001860010	2	2	30100	36200				NO SUSPENDED ITEMS
3006	16	09001865010	2	2	2900	3000				NO SUSPENDED ITEMS
3007	16	09001865010	2	2	14900	15500				NO SUSPENDED ITEMS
3008	16	09001865010	2	2	35000	43400				NO SUSPENDED ITEMS
3009	16	09001865010	2	2	27100	30000				NO SUSPENDED ITEMS
3010	16	09001865010	2	2	73200	75100				NO SUSPENDED ITEMS
110	16	09001860010	3	3	2300	3000	4000			NO SUSPENDED ITEMS
3012	16	09001865010	2	2	6000	9300				NO SUSPENDED ITEMS
3013	16	09001865010	2	2	21800	25300				NO SUSPENDED ITEMS
3014	16	09001865010	2	2	9200	66500				NO SUSPENDED ITEMS
3015	16	09001865010	2	2	128500	218700				NO SUSPENDED ITEMS
3016	16	09001865010	2	2	4300	4500				NO SUSPENDED ITEMS
3017	13	09001865010	2	2	25700	25800				NO SUSPENDED ITEMS
3018	16	09001865010	2	2	259200	315500				NO SUSPENDED ITEMS
3019	16	09001865010	2	2	47000	95300				NO SUSPENDED ITEMS
3020	16	09001865010	2	2	2000	4000				NO SUSPENDED ITEMS
3021	16	09001865010	2	2	3000	5700				NO SUSPENDED ITEMS
3022	16	09001865010	2	2	52000	62500				NO SUSPENDED ITEMS
3023	16	09001865010	2	2	61500	71000				NO SUSPENDED ITEMS
3024	16	09001865010	2	2	2900	3100				NO SUSPENDED ITEMS
3025	16	09001865010	2	2	21000	44500				NO SUSPENDED ITEMS
3026	16	09001865010	3	3	69800	80000	161500			NO SUSPENDED ITEMS
3027	23	09101960010	2	2	24000	24100				NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND CYCLES TO SUSPENSION OF TESTING WITHOUT FAILURE FOR ALL GROUPS IN THE DATA COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
3028	23	09101860010	2	2	35000	46000				NO SUSPENDED ITEMS
3029	23	09101860010	2	2	62000	74000				NO SUSPENDED ITEMS
3030	23	09101860010	2	2	99000	182060				NO SUSPENDED ITEMS
3031	23	09101860010	2	2	11000	18000				NO SUSPENDED ITEMS
3032	23	09101860010	2	2	25000	36000				NO SUSPENDED ITEMS
3033	23	09101860010	2	2	57000	65900				NO SUSPENDED ITEMS
3034	23	09101860010	2	2	112000	190000				NO SUSPENDED ITEMS
3035	23	09101860010	2	2	262000	298000				NO SUSPENDED ITEMS
3036	23	09101860010	2	2	7000	10000				NO SUSPENDED ITEMS
3037	23	09101860010	2	2	249000	274000				NO SUSPENDED ITEMS
3038	23	09101860010	2	2	657000	741000				NO SUSPENDED ITEMS
3039	23	09101860010	2	2	7000	10000				NO SUSPENDED ITEMS
3040	23	09101860010	2	2	17000	17100				NO SUSPENDED ITEMS
3041	23	09101860010	2	2	39000	44000				NO SUSPENDED ITEMS
3042	23	09101860010	2	2	27000	32000				NO SUSPENDED ITEMS
3043	23	09101860010	2	2	61000	70000				NO SUSPENDED ITEMS
3044	21	03202060010	4	4	1680	1950	2170	2470		NO SUSPENDED ITEMS
3045	21	03202060010	4	4	2470	2510	2540	3020		NO SUSPENDED ITEMS
3046	21	03202060010	3	3	2290	2870	3160			NO SUSPENDED ITEMS
3047	21	03202060010	4	4	5500	5700	5800	5850		NO SUSPENDED ITEMS
3048	21	03202060010	4	4	6910	7040	7370	8080		NO SUSPENDED ITEMS
3049	21	03202060010	4	4	10180	10390	10930	11360		NO SUSPENDED ITEMS
3050	21	03202060010	6	6	1610	17170	18860	19920	21230	NO SUSPENDED ITEMS
					25900					
3051	21	03202060010	4	4	44340	55460	56300	58600		NO SUSPENDED ITEMS
3052	21	03202060010	4	4	11530	14350	16010	17560		NO SUSPENDED ITEMS
3053	21	03202060010	4	4	18470	22560	23420	27700		NO SUSPENDED ITEMS
3054	21	03202060010	4	4	27390	33390	35820	37100		NO SUSPENDED ITEMS
3055	21	03202060010	4	4	68480	81270	82400	93810		NO SUSPENDED ITEMS
3056	21	03202060010	3	3	29920	35960	36700			NO SUSPENDED ITEMS
3057	21	03202060010	4	4	54340	57610	61360	68480		NO SUSPENDED ITEMS
3058	21	03202060010	3	3	144050	174800	188200			NO SUSPENDED ITEMS
3059	21	03202060010	4	4	456100	503060	561430	995720		NO SUSPENDED ITEMS
3060	21	03202060010	4	4	97250	89500	119630	124310		NO SUSPENDED ITEMS
3061	21	03202060010	4	4	175390	176040	204700	227693		NO SUSPENDED ITEMS
3062	21	03202060010	11	11	519320	598350	614330	661260	731090	NO SUSPENDED ITEMS
					906730	839860	856460	943117	1072730	
					1295360					
3063	23	09101860010	2	2	91000	106000				NO SUSPENDED ITEMS
3064	23	09101860010	2	2	132000	256000				NO SUSPENDED ITEMS

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE				CYCLES AT SUSPENSION
3065	23	09101860010	2	2	5000	7000			NO SUSPENDED ITEMS
3066	23	09101860010	2	2	22000	25000			NO SUSPENDED ITEMS
3067	23	09101860010	3	3	99000	145000	171000		NO SUSPENDED ITEMS
3068	23	09101860010	3	3	397000	416000	421000		NO SUSPENDED ITEMS
3069	23	09101860010	2	2	12000	13000			NO SUSPENDED ITEMS
3070	23	09101860010	2	2	16000	24000			NO SUSPENDED ITEMS
3071	23	09101860010	2	2	51000	55000			NO SUSPENDED ITEMS
3072	23	09101860010	2	2	65000	74000			NO SUSPENDED ITEMS
3073	23	09101860010	2	2	153000	280000			NO SUSPENDED ITEMS
3074	23	09101860010	2	2	837000	924000			NO SUSPENDED ITEMS
3075	23	09101860010	2	2	8000	10000			NO SUSPENDED ITEMS
3076	23	09101860010	3	3	26000	48000	48000		NO SUSPENDED ITEMS
3077	23	09101860010	4	4	133000	197000	213000	237000	NO SUSPENDED ITEMS
3078	23	09101860010	2	2	15000	17000			NO SUSPENDED ITEMS
3079	23	09101860010	2	2	18000	26000			NO SUSPENDED ITEMS
3080	23	09101860010	2	2	31000	46000			NO SUSPENDED ITEMS
3081	23	09101860010	2	2	39000	53000			NO SUSPENDED ITEMS
3082	23	09101860010	2	2	61000	63000			NO SUSPENDED ITEMS
3083	23	09101860010	2	2	162000	185000			NO SUSPENDED ITEMS
3084	23	09101860010	2	2	213000	752000			NO SUSPENDED ITEMS
3085	23	09101860010	2	2	12000	15000			NO SUSPENDED ITEMS
3086	23	09101860010	2	2	44000	84000			NO SUSPENDED ITEMS
3087	23	09101860010	2	2	53000	65000			NO SUSPENDED ITEMS
3088	23	09101860010	2	2	321000	361000			NO SUSPENDED ITEMS
3089	23	09101860010	2	2	1650	2031			NO SUSPENDED ITEMS
3090	23	09101860010	2	2	3516	4075			NO SUSPENDED ITEMS
3091	23	09101860010	2	2	8000	14000			NO SUSPENDED ITEMS
3092	23	09101860010	2	2	18000	24000			NO SUSPENDED ITEMS
3093	23	09101860010	2	2	32000	34000			NO SUSPENDED ITEMS
3094	23	09101860010	2	2	75000	113000			NO SUSPENDED ITEMS
3095	23	09101860010	2	2	350000	555000			NO SUSPENDED ITEMS
3096	23	09101860010	3	3	18000	23000	23000		NO SUSPENDED ITEMS
3097	23	09101860010	3	3	52000	58000	81000		NO SUSPENDED ITEMS
3098	23	09101860010	3	3	268000	374000	701000		NO SUSPENDED ITEMS
3099	23	09101860010	2	2	9570	15156			NO SUSPENDED ITEMS
3100	23	09101860010	2	2	31000	38000			NO SUSPENDED ITEMS
3101	23	09101860010	2	2	38000	65000			NO SUSPENDED ITEMS
3102	23	09101860010	2	2	100000	104000			NO SUSPENDED ITEMS
3103	23	09101860010	2	2	172000	409000			NO SUSPENDED ITEMS
3104	23	09101860010	2	2	8000	9000			NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	A-E DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE				CYCLES AT SUSPENSION
3105	23 09101860010	2	2	33000	43000			NO SUSPENDED ITEMS
3106	23 09101860010	3	3	138500	186000	218000		NO SUSPENDED ITEMS
3107	23 09101860010	3	3	213000	411000	1838003		NO SUSPENDED ITEMS
3108	23 09101860010	2	2	13000	19000			NO SUSPENDED ITEMS
3109	23 09101860010	2	2	51000	56000			NO SUSPENDED ITEMS
3110	23 09101860010	2	2	90000	158000			NO SUSPENDED ITEMS
3111	23 09101860010	2	2	124000	155000			NO SUSPENDED ITEMS
3112	23 09101860010	3	3	8000	9000	10000		NO SUSPENDED ITEMS
3113	23 09101860010	3	3	30000	31000	31000		NO SUSPENDED ITEMS
3114	23 09101860010	3	3	90000	112000	175000		NO SUSPENDED ITEMS
3115	23 09101860010	2	2	16000	16100			NO SUSPENDED ITEMS
3116	23 09101860010	2	2	25000	25100			NO SUSPENDED ITEMS
3117	23 09101860010	2	2	39000	46000			NO SUSPENDED ITEMS
3118	23 09101860010	3	3	62000	71000	223000		NO SUSPENDED ITEMS
3119	23 09101860010	2	2	128000	163000			NO SUSPENDED ITEMS
3120	23 09101860010	2	2	8000	9000			NO SUSPENDED ITEMS
3121	23 09101860010	3	3	29000	32900	36000		NO SUSPENDED ITEMS
3122	23 09101860010	3	3	108000	122000	125000		NO SUSPENDED ITEMS
3123	23 09101860010	3	3	340000	516000	674003		NO SUSPENDED ITEMS
3124	23 09101860010	2	2	23000	36000			NO SUSPENDED ITEMS
3125	23 09101860010	2	2	41000	57000			NO SUSPENDED ITEMS
3126	23 09101860010	2	2	50000	62000			NO SUSPENDED ITEMS
3127	23 09101860010	3	3	15000	16000	19000		NO SUSPENDED ITEMS
3128	23 09101860010	3	3	41000	55000	74000		NO SUSPENDED ITEMS
3129	23 09101860010	3	3	131000	171000	190000		NO SUSPENDED ITEMS
3130	23 09101860010	2	2	37000	41000			NO SUSPENDED ITEMS
3131	23 09101860010	3	3	88000	169000	408000		NO SUSPENDED ITEMS
3132	23 09101860010	2	2	455000	616000			NO SUSPENDED ITEMS
3133	23 09101860010	2	2	12000	13000			NO SUSPENDED ITEMS
3134	23 09101860010	2	2	29000	45000			NO SUSPENDED ITEMS
3135	23 09101860010	2	2	77000	94000			NO SUSPENDED ITEMS
3136	23 09101860010	4	4	592000	654000	843000	1777000	NO SUSPENDED ITEMS
3137	23 09101860010	2	2	41000	51000			NO SUSPENDED ITEMS
3138	23 09101860010	2	2	62000	67000			NO SUSPENDED ITEMS
3139	23 09101860010	2	2	156000	797000			NO SUSPENDED ITEMS
3140	23 09101860010	2	2	144000	501000			NO SUSPENDED ITEMS
3141	23 09101860010	2	2	309000	596000			NO SUSPENDED ITEMS
3142	23 09101860010	2	2	18000	21000			NO SUSPENDED ITEMS
3143	23 09101860010	3	3	38000	132000	140000		NO SUSPENDED ITEMS
3144	23 09101860010	3	3	240000	356000	532000		NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	REF DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION	
3145	23 09101860010	2	2	39000	131000				NO SUSPENDED ITEMS	
3146	23 09101860010	3	3	108000	154000	302000			NO SUSPENDED ITEMS	
3147	23 09101860010	3	3	127000	176000	5218000			NO SUSPENDED ITEMS	
3148	23 09101860010	2	2	8000	9000				NO SUSPENDED ITEMS	
3149	23 09101860010	2	2	16000	21000				NO SUSPENDED ITEMS	
3150	23 09101860010	2	2	118000	124000				NO SUSPENDED ITEMS	
3151	23 09101860010	2	2	67000	107000				NO SUSPENDED ITEMS	
3152	23 09101960010	2	2	228000	278000				NO SUSPENDED ITEMS	
3153	23 09101860010	2	2	451000	546000				NO SUSPENDED ITEMS	
3154	23 09101960010	2	2	16000	30000				NO SUSPENDED ITEMS	
3156	19 05902960010	4	2	180000	244000				250000	250000
3157	19 05902860010	48	16	137000	143000	147000	158000	159000*	ALL VALUES =	250000
				162000	181000	191000	192000	204000*		
				236000	240000	241000	244000	245000*		
				248000						
3158	19 05902860010	51	25	128000	153000	159000	177000	180000*	ALL VALUES =	250000
				188000	190000	194000	195000	199000*		
				199000	200000	201000	207000	210000*		
				210000	211000	215000	223000	226000*		
				228000	235000	236000	240000	249000*		
3159	19 05902860010	54	10	138000	180000	181000	193000	200000*	ALL VALUES =	250000
				215000	220000	275000	236000	250000*		
3160	19 05902960010	54	29	161000	163000	166000	170000	178000*	ALL VALUES =	250000
				185000	187000	191000	200000	204000*		
				204000	206000	208000	209000	211000*		
				219000	227000	229000	230000	233000*		
				233000	233000	237000	245000	247000*		
				248000	248000	248000	250000			
3161	19 05902860010	53	5	188000	196000	221000	234000	246000*	ALL VALUES =	250000
3162	19 05902960010	11	3	171000	173000	235000			ALL VALUES =	250000
3163	19 05902860010	5	3	171000	179000	190000			250000	250000
3164	19 05902860010	2	2	197000	218000				NO SUSPENDED ITEMS	
3165	19 05902960010	5	3	172000	174000	249000			250000	250000
3166	19 05902960010	49	33	105000	110000	115000	127000	143000*	ALL VALUES =	250000
				146000	150000	153000	161000	162000*		
				171000	176000	180000	185000	187000*		
				188000	199000	202000	205000	215000*		
				214000	216000	223000	228000	229000*		
				233000	234000	236000	236000	238000*		
				245000	248000	248000				

LISTED NUMBERS OF CYCLES TO FAILURE AND CYCLES TO SUSPENSION OF TESTING WITHOUT FAILURE FOR ALL GROUPS IN THE DATA COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
3167	19	05902960010	48	29	139000	139000	153000	153000	158000	ALL VALUES = 250000
					160000	171000	171000	175000	177000	
					178000	183000	184000	186000	187000	
					188000	191000	197000	200000	211000	
					211000	216000	218000	222000	229000	
					230000	238000	247000	248000		
3168	19	05902960010	46	12	175000	177000	177000	200000	200000	ALL VALUES = 250000
					214000	218000	221000	230000	237000	
					242000	248000				
3169	19	05902960010	46	30	96000	120000	121000	123000	137000	ALL VALUES = 250000
					139000	144000	145000	149000	153000	
					159000	163000	163000	164000	168000	
					169000	170000	176000	178000	182000	
					183000	197000	198000	203000	206000	
					209000	210000	215000	220000	223000	
3170	19	05902960010	48	8	161000	170000	180000	194000	230000	ALL VALUES = 250000
					241000	241000	250000			
3171	19	05902960010	13	4	178000	202000	207000	211000		ALL VALUES = 250000
3172	19	05902960010	8	3	169000	182000	192000			250000 250000
3173	19	05902960010	8	5	159000	199000	203000	210000	240000	250000 250000 250000
3174	19	05902960010	53	33	74000	95000	103000	110000	115000	ALL VALUES = 250000
					119000	126000	128000	140000	140000	
					140000	142000	146000	146000	149000	
					150000	154000	156000	160000	163000	
					172000	174000	175000	176000	189000	
					189000	190000	196000	200000	223000	
					234000	240000	247000			
3175	19	05902860010	53	23	109000	127000	136000	159000	165000	ALL VALUES = 250000
					174000	178000	191000	188000	193000	
					194000	204000	211000	211000	219000	
					220000	220000	226000	228000	238000	
					241000	244000	247000			
3176	19	05902960010	53	33	101000	113000	130000	134000	134000	ALL VALUES = 250000
					135000	137000	139000	148000	153000	
					164000	165000	165000	168000	172000	
					177000	183000	187000	188000	193000	
					208000	212000	213000	214000	215000	
					220000	223000	234000	237000	244000	
					244000	246000	248000			

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	REF DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION		
3177	19 05902860010	52	41	78000	111000	128000	132000	134000	ALL VALUES =	250000	
				141000	142000	142000	150000	156000			
				161000	166000	171000	182000	190000			
				191000	191000	197000	197000	198000			
				199000	201000	212000	216000	219000			
				221000	222000	223000	223000	226000			
				229000	229000	230000	235000	238000			
				240000	240000	248000	248000	249000			
				250000							
3178	19 05902860010	11	6	79000	85000	126000	175000	181000	250000	250000	250000
				237000					250000	250000	
3179	19 05902860010	11	6	149000	166000	176000	183000	220000	250000	250000	250000
				239000					250000	250000	
3180	19 05902860010	11	3	135000	228000	249000			ALL VALUES =	250000	
3181	19 05902860010	10	5	166000	174000	189000	216000	248000	250000	250000	250000
									250000	250000	
3182	19 05902860010	10	7	112000	134000	151000	161000	241000	250000	250000	250000
				246000	249000						
3183	19 05902860010	10	3	160000	225000	226000			250000	250000	250000
									250000	250000	250000
									250000		
3184	19 05902960010	47	34	91000	100000	108000	114000	118000	ALL VALUES =	250000	
				122000	134000	142000	142000	143000			
				143000	143000	146000	153000	162000			
				162000	163000	168000	173000	176000			
				179000	180000	182000	182000	194000			
				199000	200000	208000	208000	208000			
				224000	228000	236000	244000				
3185	19 05902960010	47	24	117000	126000	151000	154000	160000	ALL VALUES =	250000	
				168000	173000	179000	180000	186000			
				189000	190000	195000	196000	200000			
				218000	231000	239000	240000	244000			
				245000	248000	248000	249000				
3186	19 05902960010	47	27	101000	113000	119000	123000	130000	ALL VALUES =	250000	
				138000	141000	142000	147000	150000			
				151000	161000	163000	165000	174000			
				189000	192000	193000	199000	206000			
				211000	213000	222000	223000	227000			
				241000	245000						

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	REF DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION		
3187	19 05902960010	44	29	57000	84000	100000	106000	106000	ALL VALUES =	250000	
				112000	113000	117000	124000	125000			
				126000	128000	142000	148000	153000			
				154000	177000	180000	187000	197000			
				211000	216000	223000	227000	237000			
				240000	245000	245000	248000				
3188	19 05902960010	13	7	143000	173000	210000	214000	216000	250000	250000	250000
				223000	248000				250000	250000	250000
3189	19 05902960010	13	10	111000	155000	179000	190000	195000	250000	250000	250000
				196000	212000	226000	233000	244000			
3190	19 05902960010	12	6	124000	159000	203000	223000	232000	250000	250000	250000
				249000					250000	250000	250000
3191	19 05902960010	13	6	159000	171000	183000	188000	213000	250000	250000	250000
				228000					250000	250000	250000
									250000		
3192	19 05902960010	13	11	103000	138000	142000	142000	162000	250000	250000	
				169000	185000	190000	207000	213000			
				246000							
3193	19 05902960010	13	5	176000	194000	200000	222000	238000	ALL VALUES =	250000	

LISTED NUMBERS OF CYCLES TO FAILURE AND CYCLES TO SUSPENSION OF TESTING WITHOUT FAILURE FOR ALL GROUPS IN THE DATA COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION	
3194	19	05902860010	1086	541	57000	74000	78000	79000	84000*	ALL VALUES =	250000
					85000	91000	95000	96000	100000*		
					100000	101000	101000	103000	103000*		
					105000	106000	106000	108000	109000*		
					110000	110000	111000	111000	112000*		
					112000	113000	113000	113000	114000*		
					115000	115000	117000	117000	118000*		
					119000	119000	120000	121000	122000*		
					123000	123000	124000	124000	125000*		
					126000	126000	126000	126000	127000*		
					127000	128000	128000	128000	128000*		
					130000	130000	132000	132000	134000*		
					134000	134000	134000	134000	135000*		
					135000	137000	137000	138000	138000*		
					138000	138000	139000	139000	139000*		
					139000	140000	140000	140000	141000*		
					141000	142000	142000	142000	142000*		
					142000	142000	142000	142000	142000*		
					143000	143000	143000	143000	143000*		
					143000	144000	145000	146000	146000*		
					146000	146000	147000	147000	148000*		
					148000	149000	149000	149000	150000*		
					150000	150000	150000	151000	151000*		
					151000	153000	153000	153000	153000*		
					153000	153000	153000	153000	154000*		
					154000	154000	155000	156000	156000*		
					158000	158000	159000	159000	159000*		
					159000	159000	159000	159000	160000*		
					160000	160000	160000	161000	161000*		
					161000	161000	161000	161000	162000*		
					162000	162000	162000	162000	163000*		
					163000	163000	163000	163000	163000*		
					164000	164000	165000	165000	165000*		
					165000	166000	166000	166000	166000*		
					168000	168000	168000	168000	169000*		
					169000	169000	170000	170000	170000*		
					171000	171000	171000	171000	171000*		
					171000	171000	172000	172000	172000*		
					173000	173000	173000	173000	174000*		
					174000	174000	174000	174000	175000*		
					175000	175000	175000	176000	176000*		
					176000	176000	176000	176000	177000*		
					177000	177000	177000	177000	177000*		
					178000	178000	178000	178000	178000*		
					179000	179000	179000	179000	180000*		
					180000	180000	180000	180000	180000*		
					180000	180000	181000	181000	181000*		
					181000	182000	182000	182000	182000*		

•	182000	183000	183000	183000	183000*
•	183000	184000	185000	185000	185000*
•	186000	186000	187000	187000	187000*
•	187000	187000	188000	188000	188000*
•	188000	188000	188000	188000	189000*
•	189000	189000	189000	189000	190000*
•	190000	190000	190000	190000	190000*
•	190000	191000	191000	191000	191000*
•	191000	192000	192000	192000	193000*
•	193000	193000	193000	194000	194000*
•	194000	194000	194000	195000	195000*
•	195000	196000	196000	196000	196000*
•	197000	197000	197000	197000	197000*
•	197000	198000	198000	199000	199000*
•	199000	199000	199000	199000	199000*
•	200000	200000	200000	200000	200000*
•	200000	200000	200000	200000	200000*
•	201000	201000	202000	202000	203000*
•	203000	203000	204000	204000	204000*
•	204000	205000	206000	206000	206000*
•	207000	207000	207000	208000	208000*
•	208000	208000	208000	209000	209000*
•	210000	210000	210000	210000	210000*
•	211000	211000	211000	211000	211000*
•	211000	211000	211000	211000	212000*
•	212000	212000	213000	213000	213000*
•	213000	214000	214000	214000	214000*
•	215000	215000	215000	215000	215000*
•	216000	216000	216000	216000	216000*
•	216000	218000	218000	218000	218000*
•	219000	219000	219000	220000	220000*
•	220000	220000	220000	220000	221000*
•	221000	221000	222000	222000	222000*
•	222000	223000	223000	223000	223000*
•	223000	223000	223000	223000	223000*
•	223000	223000	224000	225000	225000*
•	226000	226000	226000	226000	226000*
•	227000	227000	227000	228000	228000*
•	229000	228000	228000	228000	229000*
•	229000	229000	229000	229000	230000*
•	230000	230000	230000	230000	231000*
•	232000	233000	233000	233000	233000*
•	233000	234000	234000	234000	235000*
•	235000	235000	236000	236000	236000*
•	236000	236000	236000	236000	237000*
•	237000	237000	237000	237000	238000*
•	238000	238000	238000	238000	239000*
•	239000	240000	240000	240000	240000*
•	240000	240000	240000	241000	241000*
•	241000	241000	241000	241000	242000*
•	244000	244000	244000	244000	244000*
•	244000	244000	244000	245000	245000*
•	245000	245000	245000	245000	245000*
•	246000	246000	246000	246000	247000*
•	247000	247000	247000	248000	248000*
•	248000	248000	248000	248000	248000*
•	248000	248000	248000	248000	248000*
•	248000	248000	248000	248000	248000*

•	249000	249000	249000	249000	249000•
•	249000	249000	250000	250000	250000•
•	250000				•

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
31-5	15	C5502860010	550	222	96000	105000	110000	119000	120000*	ALL VALUES = 250000
					121000	123000	127300	128000	132000*	
					137000	138000	139300	139000	139000*	
					143000	143300	144000	145000	146300*	
					147000	149000	150000	153000	153000*	
					153000	153000	153300	154000	158000*	
					159000	159000	159000	159000	160000*	
					161000	161000	161000	162000	162000*	
					163000	163000	163000	164000	166000*	
					168000	169000	169300	170000	170000*	
					170000	171000	171000	171000	171000*	
					171000	172000	173000	174000	175000*	
					175000	176000	176300	177000	177000*	
					177000	177000	178000	179000	178000*	
					178000	179300	180000	180000	180000*	
					180000	180300	181000	181000	182000*	
					182000	183000	183000	184000	185000*	
					185000	186000	187000	187000	187000*	
					188000	188000	189000	188000	190000*	
					190000	191000	191300	191000	192000*	
					192000	193000	194000	194000	195000*	
					196000	197000	197000	197000	198000*	
					199000	199000	199000	199000	200000*	
					200000	200300	200000	200000	200000*	
					201000	202000	202000	203000	203000*	
					204000	204000	204000	205000	206000*	
					206000	207000	207000	208000	209000*	
					209000	210000	210000	210000	210000*	
					211000	211000	211000	211000	211000*	
					214000	215000	215000	215000	215000*	
					216000	216000	216000	218000	218000*	
					218000	219000	220000	220000	221000*	
					221000	222000	223000	223000	223000*	
					225000	226000	227000	228000	228000*	
					229000	229000	229000	230000	230000*	
					230000	230000	233000	233000	233000*	
					233000	234000	234000	235000	235000*	
					236000	236000	236000	236000	236000*	
					237000	237000	238000	238000	240000*	
					240000	241000	241000	241000	242000*	
					244000	244000	245000	245000	245000*	
					246000	247000	247000	248000	248000*	
					248000	248000	248000	248000	248000*	
					248000	248000	249000	249000	250000*	
					250000	250000				

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM REF DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
3196 19 05002460010	536	315	57000	76000	78000	79000	84000	ALL VALUES = 250000
			85000	91000	95000	100000	100000	
			101000	101000	103000	103000	106000	
			106000	108000	109000	110000	111000	
			111000	112000	112000	113000	113000	
			113000	114000	115000	117000	117000	
			118000	119000	119000	122000	123000	
			124000	124000	125000	126000	126000	
			126000	126000	127000	128000	128000	
			128000	130000	130000	132000	134000	
			134000	134000	134000	134000	135000	
			135000	137000	138000	138000	138000	
			139000	140000	140000	140000	141000	
			141000	142000	142000	142000	142000	
			142000	142000	142000	142000	142000	
			143000	143000	143000	143000	146000	
			146000	146000	147000	148000	148000	
			149000	149000	150000	150000	150000	
			151000	151000	151000	153000	153000	
			153000	154000	154000	154000	155000	
			156000	156000	159000	159000	159000	
			160000	160000	160000	161000	161000	
			161000	162000	162000	162000	163000	
			163000	163000	164000	165000	165000	
			165000	165000	166000	166000	166000	
			168000	168000	168000	169000	171000	
			171000	172000	172000	173000	173000	
			173000	174000	174000	174000	174000	
			175000	175000	176000	176000	176000	
			176000	177000	177000	178000	179000	
			179000	179000	180000	180000	180000	
			181000	181000	182000	182000	182000	
			183000	183000	183000	185000	186000	
			187000	187000	188000	188000	188000	
			189000	189000	189000	189000	189000	
			190000	190000	190000	190000	190000	
			191000	191000	192000	193000	193000	
			193000	194000	194000	194000	195000	
			195000	196000	196000	196000	197000	
			197000	197000	198000	199000	199000	
			199000	200000	200000	200000	200000	
			201000	203000	204000	206000	207000	
			208000	208000	208000	208000	210000	
			211000	211000	211000	211000	212000	
			212000	212000	213000	213000	213000	
			213000	214000	214000	214000	215000	
			216000	216000	216000	218000	219000	
			219000	220000	220000	220000	220000	

•	221000	222000	222000	222000	223000 •
•	223000	223000	225000	223000	223000 •
•	223000	223000	224000	225000	226000 •
•	226000	226000	226000	227000	227000 •
•	228000	228000	228000	228000	229000 •
•	229000	230000	231000	232000	233000 •
•	234000	235000	236000	236000	237000 •
•	237000	237000	238000	238000	238000 •
•	239000	239000	240000	240000	240000 •
•	240000	240000	241000	241000	241000 •
•	244000	244000	244000	244000	244000 •
•	244000	245000	245000	245000	245000 •
•	246000	246000	246000	247000	247000 •
•	248000	248000	248000	248000	248000 •
•	249000	248000	248000	248000	249000 •
•	249000	249000	249000	250000	•

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
3201	17	19702865010	3	3	85000	89000	110000			NO SUSPENDED ITEMS
3202	17	19702865010	3	3	82000	129000	137000			NO SUSPENDED ITEMS
3203	17	19702865010	2	2	136000	167000				NO SUSPENDED ITEMS
3204	17	19702865010	2	2	237000	247000				NO SUSPENDED ITEMS
3205	17	19702865010	20	20	122000	149000	153000	161000	163000	NO SUSPENDED ITEMS
					163000	184000	187000	194000	194000	
					195000	199000	202000	204000	205000	
					212000	212000	212000	216000	216000	
3206	17	19702865010	15	15	655000	670000	707000	734000	740000	NO SUSPENDED ITEMS
					841000	867000	884000	915000	930000	
					980000	1000000	1011000	1018000	1060000	
3240	21	03202060010	4	4	1270	1290	1300	1400		NO SUSPENDED ITEMS
3241	21	03202060010	4	4	1520	1610	1650	1920		NO SUSPENDED ITEMS
3400	13	09001865050	6	6	183471	191682	193096	200997	200997	NO SUSPENDED ITEMS
					205594					
3401	13	09001865050	6	6	932346	941196	997016	1242870	1259784	NO SUSPENDED ITEMS
					1400440					
3402	14	09001865050	6	6	28070	28245	32305	33215	36015	NO SUSPENDED ITEMS
					36015					
3403	14	09001865050	6	6	23695	23960	24710	25025	26670	NO SUSPENDED ITEMS
					31045					
3404	14	09001865050	6	6	21070	22005	23975	27125	29225	NO SUSPENDED ITEMS
					30555					
3405	14	09001865050	6	6	23660	27060	27109	29055	29300	NO SUSPENDED ITEMS
					31272					
3406	14	09001865050	6	6	26197	26757	29310	32904	33019	NO SUSPENDED ITEMS
					35536					
3407	14	09001865050	6	6	88191	88366	101631	101631	119793	NO SUSPENDED ITEMS
					119828					
3408	14	09001865050	6	6	24123	24123	24158	24299	29323	NO SUSPENDED ITEMS
					30593					
3409	14	09001865050	6	6	15925	21124	21124	23375	23585	NO SUSPENDED ITEMS
					24220					
3410	14	09001865050	6	6	87640	89250	91560	94710	94710	NO SUSPENDED ITEMS
					98053					
3411	14	09001865050	6	6	66710	70245	72905	73990	79170	NO SUSPENDED ITEMS
					92085					
3412	14	09001865050	6	6	68775	73920	74585	80325	89600	NO SUSPENDED ITEMS
					91945					

LISTED NUMBERS OF CYCLES TO FAILURE AND
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COLLECTION

ITEM	REF DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
3413	14 09001865050	6	6	76399	81609	83183	88376	91351	NO SUSPENDED ITEMS
				99767					
3414	14 09001865050	6	6	72646	74326	74326	77641	85669	NO SUSPENDED ITEMS
				90393					
3415	14 09001865050	6	6	177369	177439	212022	226931	237959	NO SUSPENDED ITEMS
				240694					
3416	14 09001865050	6	6	60243	63148	74462	76379	82004	NO SUSPENDED ITEMS
				88391					
3417	14 09001865050	6	6	62372	62407	64953	66493	76493	NO SUSPENDED ITEMS
				84892					
3418	14 09001865050	6	6	51415	52710	56105	58415	60235	NO SUSPENDED ITEMS
				71330					
3419	14 09001865050	6	6	46555	49175	49175	49409	49490	NO SUSPENDED ITEMS
				55265					
3420	14 09001865050	6	6	140245	141890	143115	151900	161179	NO SUSPENDED ITEMS
				173215					
3421	14 09001865050	6	6	75705	77105	77420	78120	92575	NO SUSPENDED ITEMS
				92575					
3422	14 09001865050	6	6	79520	93975	99540	100765	104440	NO SUSPENDED ITEMS
				119280					
3423	14 09001865050	6	6	112700	114135	115900	122220	126079	NO SUSPENDED ITEMS
				136570					
3424	14 09001865050	6	6	132580	134480	142615	147955	149040	NO SUSPENDED ITEMS
				152390					
3425	14 09001865050	6	6	354165	366070	413900	422790	474905	NO SUSPENDED ITEMS
				502965					
3426	14 09001865050	6	6	86560	91315	91315	91315	96460	NO SUSPENDED ITEMS
				99995					
3427	14 09001865050	6	6	56455	62475	65030	71575	71785	NO SUSPENDED ITEMS
				72660					
3428	14 09001865050	6	6	117495	124635	137220	163405	165550	NO SUSPENDED ITEMS
				165950					
3429	14 09001865050	6	6	103040	112000	117145	123620	133420	NO SUSPENDED ITEMS
				137060					
3430	14 09001865050	6	6	75075	90825	92750	93065	95060	NO SUSPENDED ITEMS
				100695					
3431	14 09001865050	6	6	67445	76060	83265	83790	87050	NO SUSPENDED ITEMS
				97615					
3432	14 09001865050	6	6	65535	69005	76405	81305	82215	NO SUSPENDED ITEMS
				96105					

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COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
3633	14	09001865050	6	6	101605	112000	113540	114660	118930	NO SUSPENDED ITEMS
					125965					
3634	14	09001965050	6	6	96425	101700	103110	113090	115000	NO SUSPENDED ITEMS
					125990					
3635	14	09001865050	6	6	114310	126305	132790	136815	139055	NO SUSPENDED ITEMS
					144900					
3636	14	09001865050	6	6	78120	83685	83685	100135	108640	NO SUSPENDED ITEMS
					108710					
3637	14	09001865050	6	6	74200	76615	79450	79450	90230	NO SUSPENDED ITEMS
					108450					
3638	14	09001865050	6	6	124880	139265	144980	159040	162540	NO SUSPENDED ITEMS
					172060					
3639	14	09001865050	6	6	100625	106575	107730	115780	124915	NO SUSPENDED ITEMS
					139475					
3640	14	09001865050	6	6	113050	139475	158290	157460	160370	NO SUSPENDED ITEMS
					160370					
3641	14	09001865050	6	6	84490	100520	103495	109550	121170	NO SUSPENDED ITEMS
					121590					
3642	14	09001865050	6	6	105210	123130	124180	125095	130305	NO SUSPENDED ITEMS
					132405					
3643	17	19702865070	10	10	93	103	103	105	167	NO SUSPENDED ITEMS
					109	113	113	122	130	
3644	17	19702865070	10	10	99	103	107	110	132	NO SUSPENDED ITEMS
					136	137	140	147	152	
3645	17	19702865070	10	10	76	106	111	113	115	NO SUSPENDED ITEMS
					115	129	131	136	139	
3646	17	19702965070	10	10	67	77	114	117	118	NO SUSPENDED ITEMS
					120	121	124	134	162	
3647	17	19702865080	20	20	100	110	133	135	140	NO SUSPENDED ITEMS
					157	163	165	165	170	
					180	183	185	200	201	
					205	215	240	253	280	
3600	21	03202060010	3	3	332046	374560	413760			NO SUSPENDED ITEMS
3640	21	03202060010	4	4	2023910	4023400	4910410	5505740		NO SUSPENDED ITEMS
3650	4	30006855830	10	10	15060	18000	18000	18000	20000	NO SUSPENDED ITEMS
					20000	22000	24000	26000	28000	
3651	4	30004855830	10	10	89000	114000	121000	135000	141000	NO SUSPENDED ITEMS
					146000	150000	161000	163000	171000	

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COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
3652	4	30006855830	11	11	377000	425000	445000	483000	523000	NO SUSPENDED ITEMS
					606000	1032000	1167000	1250000	2082000	
					2616000					
3653	4	30006855830	10	10	334000	652000	699000	782000	805000	NO SUSPENDED ITEMS
					1096000	1069000	1110000	1114000	1437000	
3654	4	30006855830	10	10	643000	714000	988000	1084000	1152000	NO SUSPENDED ITEMS
					1465000	1563000	1771000	1941000	2481000	
3655	4	30006855830	10	10	317000	547000	650000	734000	745000	NO SUSPENDED ITEMS
					835000	840700	846000	899000	1224000	
3656	4	30006855830	10	10	378000	391000	496000	513000	600000	NO SUSPENDED ITEMS
					697000	1013000	1074000	1161000	1483000	
3657	4	30006955830	10	10	606000	665000	667000	824000	842000	NO SUSPENDED ITEMS
					996000	1057000	1133000	1943000	2505000	
3658	4	30006455830	10	10	141000	142000	156000	160000	169000	NO SUSPENDED ITEMS
					328000	383000	490000	509000	690000	
3659	4	30006855830	10	10	217000	252000	298000	306000	328000	NO SUSPENDED ITEMS
					368000	391000	439000	449000	659000	
3660	4	30006855830	10	10	185000	252000	263000	353000	405000	NO SUSPENDED ITEMS
					541000	567000	587000	651000	704000	
3661	4	30006855830	10	10	210000	225000	259000	263000	275000	NO SUSPENDED ITEMS
					317000	339000	516000	611000	830000	
3662	4	30006955830	10	10	110000	113000	129000	130000	254000	NO SUSPENDED ITEMS
					272000	300000	320000	422000	434000	
3663	4	30006855830	10	10	223000	242000	261000	272000	276000	NO SUSPENDED ITEMS
					316000	323000	323000	378000	386000	
3664	22	03202055010	4	4	48460	57630	60020	63300		NO SUSPENDED ITEMS
3665	22	03202055010	3	3	26270	28680	34830			NO SUSPENDED ITEMS
3666	22	03202055010	3	3	210650	235150	318700			NO SUSPENDED ITEMS
3667	22	03202055010	4	4	47090	53660	56100	58570		NO SUSPENDED ITEMS
3668	22	03202055010	4	4	23380	26090	30363	33410		NO SUSPENDED ITEMS
3669	22	03202055010	4	4	186860	199240	202013	209190		NO SUSPENDED ITEMS
3670	22	03202055010	4	4	40490	42540	42610	43170		NO SUSPENDED ITEMS
3671	22	03202055010	4	4	32590	37190	37820	47559		NO SUSPENDED ITEMS
3672	22	03202055010	4	4	240660	285700	298630	347680		NO SUSPENDED ITEMS
3673	22	03202055010	4	4	397590	403900	542380	610410		NO SUSPENDED ITEMS
3674	22	03202055010	6	6	387740	393450	395040	564640	588610	NO SUSPENDED ITEMS
					598740					
3675	22	03202055010	3	3	26270	28680	34830			NO SUSPENDED ITEMS
3676	22	03202055010	4	4	47330	99550	99570	100250		NO SUSPENDED ITEMS
3677	22	03202055010	4	4	114110	171310	202430	706370		NO SUSPENDED ITEMS

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
3678	22	03202055010	4	4	177980	189210	190590	195400		NO SUSPENDED ITEMS
3679	22	03202055010	4	4	34500	38330	50470	51770		NO SUSPENDED ITEMS
3680	22	03202055010	4	4	48120	48370	49820	62900		NO SUSPENDED ITEMS
3681	22	03202055010	4	4	92400	154480	162630	202370		NO SUSPENDED ITEMS
3682	22	03202055010	4	4	178440	181710	182810	184190		NO SUSPENDED ITEMS
3920	4	30006855830	20	20	393000	699000	776000	796000	792000	NO SUSPENDED ITEMS
					896000	1147000	1190000	1220000	1349000	
					1370000	1474000	1510000	1595000	1693000	
					1726000	1792000	1796000	2242000	4700000	
3921	4	30006855830	20	20	2292000	3993000	4013000	4130000	4570000	NO SUSPENDED ITEMS
					4901000	5093000	5170000	5343000	6257000	
					6521000	6957000	7331000	7422000	7576000	
					8236000	8239000	11864000	12493000	17528000	
3922	4	30006855830	10	10	2224000	2464000	2482000	2706000	2766000	NO SUSPENDED ITEMS
					2882000	3098000	3650000	4162000	4223000	
3923	4	30006855830	10	10	12090000	13093000	13206000	13631000	16536000	NO SUSPENDED ITEMS
					17867000	22119000	23178000	29890000	50278000	
3924	4	30006855830	11	11	19082000	33740000	63674000	89681000	90265000	NO SUSPENDED ITEMS
					100725000	106542000	117843000	118000000	270169000	
					317912000					
3925	4	30006855830	10	7	47425000	53962000	91034000	183979000	247310000	598847000 598847000 602000000
					499637000	516414000				
3926	4	30006855830	11	11	1158000	1304000	1505000	1544000	1555000	NO SUSPENDED ITEMS
					2225000	2467000	2709000	3139000	3835000	
					4972000					
3927	4	30006855830	10	10	3312000	5200000	6594000	9014000	12231000	NO SUSPENDED ITEMS
					19260000	19670000	23186000	24456000	24574000	
3928	4	30006855830	10	10	19540000	18783000	22354000	28510000	35247000	NO SUSPENDED ITEMS
					39360000	40983000	47717000	56163000	64429000	
3929	4	30006855830	10	10	597000	1330000	1704000	2028000	2879000	NO SUSPENDED ITEMS
					3138000	3302000	4026000	4666000	6787000	
3930	4	30006855830	10	10	2668000	3442000	3903000	4334000	4664000	NO SUSPENDED ITEMS
					5338000	5447000	5614000	5656000	5884000	
3931	4	30006855830	10	10	976000	1156000	1451000	1806000	2021000	NO SUSPENDED ITEMS
					2061000	2248000	2569000	2899000	3929000	
3932	4	30006855830	10	10	1190000	1360000	1389000	1555000	2057000	NO SUSPENDED ITEMS
					2632000	5830000	5920000	7684000	13731000	
3933	4	30006855830	10	10	3560000	3832000	6092000	6785000	7246000	NO SUSPENDED ITEMS
					14090000	15438000	21517000	28310000	30764000	

LISTED NUMBERS OF CYCLES TO FAILURE AND
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COLLECTION

ITEM	SEF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
3934	6	30006355830	10	10	1526000	1673000	1997300	2100000	2599000	NO SUSPENDED ITEMS
					2534000	2828000	3610000	4226000	5143000	
3935	6	30006355830	10	10	1778000	3092000	3121000	3624000	4545000	NO SUSPENDED ITEMS
					5208000	7605000	8118000	9470000	11716000	
3936	6	30006455830	10	10	1974000	4124000	5231000	5466000	5592000	NO SUSPENDED ITEMS
					6210000	6882000	7680000	8076000	10114000	
3937	6	30006455830	10	10	481000	760000	833000	1224000	2041000	NO SUSPENDED ITEMS
					2414000	3441000	4260000	4371000	5776000	
3938	6	30006355830	10	10	540000	1255000	1302000	1442000	1497000	NO SUSPENDED ITEMS
					1801000	1879000	2197000	2679000	4097000	
3939	6	30006455430	10	10	772000	860000	928000	932000	1035000	NO SUSPENDED ITEMS
					1049000	1051000	2316000	2340000	2403000	
3940	6	30006455830	10	10	938000	969000	1592000	1845000	1875000	NO SUSPENDED ITEMS
					1915000	1940000	2235000	3008000	6758000	
3941	22	03202055010	4	4	217960	1827370	2044240	2143430		NO SUSPENDED ITEMS
3942	22	03202055010	4	4	1151800	1587080	1768730	1949860		NO SUSPENDED ITEMS
3943	22	03202055010	4	4	1562890	1767900	2121510	2603550		NO SUSPENDED ITEMS
3944	22	03202055010	4	4	696690	788620	1139140	1454940		NO SUSPENDED ITEMS
4000	5	03102021010	6	6	6000	6200	6340	6700	7320	NO SUSPENDED ITEMS
					8400					
4001	5	03102021010	3	3	15600	15800	19800			NO SUSPENDED ITEMS
4002	5	03102021010	3	3	26100	35200	39100			NO SUSPENDED ITEMS
4003	5	03102021010	3	3	86500	89400	130500			NO SUSPENDED ITEMS
4004	5	03102021010	3	3	521700	775200	779100			NO SUSPENDED ITEMS
4005	5	03102021010	3	3	49000	48500	66200			NO SUSPENDED ITEMS
4006	5	03102021010	3	3	127700	134500	164200			NO SUSPENDED ITEMS
4007	5	03102021010	3	3	592300	645000	761800			NO SUSPENDED ITEMS
4008	5	03102021010	3	3	20000	21700	25600			NO SUSPENDED ITEMS
4009	5	03102021010	3	3	69000	83600	114700			NO SUSPENDED ITEMS
4010	5	03102021010	2	2	128000	131600				NO SUSPENDED ITEMS
4011	6	03902028010	3	2	3000	31000				88000
4012	6	03902028010	3	3	114000	258000	300000			NO SUSPENDED ITEMS
4013	6	03902028010	3	2	30000	258000				114000
4014	6	03902028010	3	3	4000	5000	7000			NO SUSPENDED ITEMS
4015	6	03902028010	3	3	43000	63000	64000			NO SUSPENDED ITEMS
4016	6	03902028010	3	3	593000	767000	990000			NO SUSPENDED ITEMS
4017	6	03902028010	2	2	416000	614000				NO SUSPENDED ITEMS
4018	6	03902021010	3	3	52000	57000	70000			NO SUSPENDED ITEMS
4019	6	03902021010	3	3	59000	60000	61000			NO SUSPENDED ITEMS
4020	6	03902021010	3	3	139000	159000	248000			NO SUSPENDED ITEMS

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COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
4021	6	03902021010	3	3	146000	151000	172000			NO SUSPENDED ITEMS
4022	6	03902021010	3	3	201000	283000	408000			NO SUSPENDED ITEMS
4023	6	03902021010	3	3	328000	366000	459600			NO SUSPENDED ITEMS
4024	6	03902021010	2	2	927000	1395000				NO SUSPENDED ITEMS
4025	6	03902021010	3	3	430000	568000	836000			NO SUSPENDED ITEMS
4026	6	03902021010	3	3	387000	619000	1015000			NO SUSPENDED ITEMS
4027	6	03902021010	7	7	52000	57000	59000	60000	61000	NO SUSPENDED ITEMS
					63000	70000				
4028	6	03902021010	7	7	139000	146000	151000	159000	172000	NO SUSPENDED ITEMS
					226000	248000				
4029	6	03902021010	6	6	201000	283000	328000	366000	406000	NO SUSPENDED ITEMS
					459000					
4030	6	03902021010	8	8	387000	430000	568000	619000	836000	NO SUSPENDED ITEMS
					927000	1015000	1395000			
4031	7	03102021010	4	4	32800	37000	39400	50500		NO SUSPENDED ITEMS
4032	7	03102021010	2	2	63200	66700				NO SUSPENDED ITEMS
4033	7	03102021010	3	3	79000	92600	161200			NO SUSPENDED ITEMS
4034	7	03102021010	6	6	374500	423600	499300	891400	1067600	NO SUSPENDED ITEMS
					2959800					
4035	7	03102021010	3	3	39500	43800	47900			NO SUSPENDED ITEMS
4036	7	03102021010	3	3	23500	69900	84700			NO SUSPENDED ITEMS
4037	7	03102021010	3	3	75100	127500	201400			NO SUSPENDED ITEMS
4038	7	03102021010	3	3	275700	526100	766700			NO SUSPENDED ITEMS
4039	7	03102021010	3	3	813700	866900	1108200			NO SUSPENDED ITEMS
4040	7	03102021010	3	3	26500	36700	41800			NO SUSPENDED ITEMS
4041	7	03102021010	3	3	47200	61400	83100			NO SUSPENDED ITEMS
4042	7	03102021010	3	3	52300	88400	118800			NO SUSPENDED ITEMS
4043	7	03102021010	3	3	207000	269500	299100			NO SUSPENDED ITEMS
4044	7	03102021010	3	3	38100	52600	53100			NO SUSPENDED ITEMS
4045	7	03102021010	3	3	43300	53100	85300			NO SUSPENDED ITEMS
4046	7	03102021010	3	3	115200	121700	148300			NO SUSPENDED ITEMS
4047	7	03102021010	4	4	126600	175100	367600	523400		NO SUSPENDED ITEMS
4048	7	03102021010	3	3	33200	37300	41000			NO SUSPENDED ITEMS
4049	7	03102021010	3	3	41800	43300	58500			NO SUSPENDED ITEMS
4050	7	03102021010	3	3	45700	75000	101900			NO SUSPENDED ITEMS
4051	7	03102021010	3	3	241500	311100	460900			NO SUSPENDED ITEMS
4052	7	03102021010	3	3	170900	330200	714300			NO SUSPENDED ITEMS
4053	7	03102021010	3	3	746600	979900	2062000			NO SUSPENDED ITEMS

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
4054	7	03102021010	12	12	26500	33200	36700	37300	38100	NO SUSPENDED ITEMS
					39500	41000	41800	44800	47900	
					52600	53100				
4055	7	03102021010	12	12	23500	41800	43500	43900	47200	NO SUSPENDED ITEMS
					53100	58500	61400	69900	83100	
					84700	85300				
4056	7	03102021010	12	12	45700	57100	65000	75100	88400	NO SUSPENDED ITEMS
					101900	115200	118800	121700	127500	
					148300	201400				
4057	7	03102021010	13	13	126600	175100	207000	241500	269500	NO SUSPENDED ITEMS
					275700	299100	311100	367600	460900	
					523400	526100	766700			
4058	7	03102021010	13	13	170500	390200	563900	714300	813700	NO SUSPENDED ITEMS
					966900	1108200	1185800	1274300	2080400	
					2505300	2542000	2674500			
4059	2	03102921010	3	3	85000	99000	109000			NO SUSPENDED ITEMS
4060	2	03102421010	3	3	124000	152000	182000			NO SUSPENDED ITEMS
4061	2	03102321010	3	3	202000	273000	357000			NO SUSPENDED ITEMS
4062	2	03102521010	3	3	504000	638000	643000			NO SUSPENDED ITEMS
4063	2	03102921010	2	2	197000	199000				NO SUSPENDED ITEMS
4064	2	03102923010	3	3	499000	602000	679000			NO SUSPENDED ITEMS
4065	2	03102923010	2	2	664000	1029000				NO SUSPENDED ITEMS
4066	2	03102928010	3	3	280000	460000	522000			NO SUSPENDED ITEMS
4067	46	15601821010	4	4	64000	66000	87000	97000		NO SUSPENDED ITEMS
4068	20	03102021010	10	10	53000	61000	67000	67000	70000	NO SUSPENDED ITEMS
					71000	73000	76000	79000	90000	
4069	20	03102021010	10	10	184000	199000	202000	207000	207000	NO SUSPENDED ITEMS
					234000	246000	255000	273000	282000	
4070	20	03102021010	10	10	457000	498000	585000	592000	608000	NO SUSPENDED ITEMS
					641000	663000	667000	802000	1173000	
4071	58	04002921010	2	2	180500	201200				NO SUSPENDED ITEMS
4072	58	04002921011	2	2	180400	197300				NO SUSPENDED ITEMS
4073	58	04002921010	3	3	55100	65600	83000			NO SUSPENDED ITEMS
4074	58	04002921011	3	3	55100	65600	69600			NO SUSPENDED ITEMS
4075	58	04002921010	4	4	92700	105700	137400	159900		NO SUSPENDED ITEMS
4076	58	04002981011	2	2	99100	84200				NO SUSPENDED ITEMS
4077	55	04002029010	6	6	58800	60200	61400	62100	62300	NO SUSPENDED ITEMS
					63700					
4078	55	04002029011	5	5	28800	42900	46200	46500	64800	NO SUSPENDED ITEMS

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
4079	58	04002029010	6	6	37900	41000	45203	50500	54600	NO SUSPENDED ITEMS
					58600					
4080	58	04002029011	4	4	30200	34200	34300	43000		NO SUSPENDED ITEMS
4081	58	04002922010	6	6	22500	24400	24600	27000	30300	NO SUSPENDED ITEMS
					40000					
4082	58	04002922011	5	5	17000	21600	23100	24700	28000	NO SUSPENDED ITEMS
4083	58	04002922010	6	6	25600	27500	30800	35700	36600	NO SUSPENDED ITEMS
					69200					
4084	58	04002922011	5	5	24700	24700	33500	34400	64800	NO SUSPENDED ITEMS
4085	73	03102021010	20	20	87000	96000	100000	104000	105000	NO SUSPENDED ITEMS
					105000	106000	112000	115000	115000	
					121000	121000	122000	123000	124000	
					126000	128000	130000	139000	157000	
4086	73	03102321010	10	10	90000	114000	115000	119000	124000	NO SUSPENDED ITEMS
					126000	128000	131000	133000	135000	
4087	72	00001806010	4	4	3416	3983	4548	5524		NO SUSPENDED ITEMS
4088	72	00001806010	4	4	10000	11000	13000	14000		NO SUSPENDED ITEMS
4089	72	00001806010	4	4	82000	82000	96000	108000		NO SUSPENDED ITEMS
4090	72	00001806010	5	5	118000	13000	205000	298000	362000	NO SUSPENDED ITEMS
4091	72	00001806010	4	4	3939	4095	4360	7325		NO SUSPENDED ITEMS
4092	72	00001806010	4	4	9000	9000	15000	16000		NO SUSPENDED ITEMS
4093	72	00001806010	4	4	254000	499000	501000	535000		NO SUSPENDED ITEMS
4094	72	00001806010	4	4	5000	8000	8000	8003		NO SUSPENDED ITEMS
4095	72	00001806010	4	4	54000	55000	56003	65000		NO SUSPENDED ITEMS
4096	72	00001806010	4	4	425000	431000	436000	457000		NO SUSPENDED ITEMS
4097	72	00001806010	4	4	32000	35000	42300	46000		NO SUSPENDED ITEMS
4098	72	00001806010	4	4	93000	85000	91000	141000		NO SUSPENDED ITEMS
4099	72	00001806010	4	4	178000	270000	509000	619000		NO SUSPENDED ITEMS
4100	72	00001806010	5	5	4000	4595	5000	5000	6000	NO SUSPENDED ITEMS
4101	72	00001806010	2	2	4996	5638				NO SUSPENDED ITEMS
4102	72	00001806010	5	5	10000	11000	11185	14000	19000	NO SUSPENDED ITEMS
4103	72	00001806010	4	4	38000	54000	57000	62000		NO SUSPENDED ITEMS
4104	72	00001806010	4	4	236000	253000	320000	530000		NO SUSPENDED ITEMS
4105	72	00001806010	4	4	2000	5000	5000	5000		NO SUSPENDED ITEMS
4106	72	00001806010	4	4	19000	37000	48300	50000		NO SUSPENDED ITEMS
4107	72	00001806010	4	4	250000	268000	274000	898000		NO SUSPENDED ITEMS
4108	72	00001806010	3	3	4306	4556	5208			NO SUSPENDED ITEMS
4109	72	00001806010	3	3	5049	5925	6129			NO SUSPENDED ITEMS
4110	72	00001806010	4	4	7000	7000	8000	8009		NO SUSPENDED ITEMS
4111	72	00001806010	4	4	8000	9000	11000	13000		NO SUSPENDED ITEMS

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ITEM NO.	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
[illegible]	[illegible]	4	4	18000	21000	22000	32000		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	37000	41000	52000	56000		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	125000	139000	171000	412000		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	366000	471000	475000	465000		NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	418000	514000	661000			NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	3616	4202	5188	5601		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	4000	3000	10000	13000		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	17000	22000	26000	33000		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	48000	52000	67000	170000		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	352000	456000	592000	1096000		NO SUSPENDED ITEMS
[illegible]	[illegible]	10	10	346000	471000	475000	458000	465000	NO SUSPENDED ITEMS
				513000	641000	987000	1157000	1495000	
[illegible]	[illegible]	[illegible]	[illegible]	13	71	198	280	409	NO SUSPENDED ITEMS
				618					
[illegible]	[illegible]		3	1082	1375	1607			NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	1680	1864	1961	2055		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	2629	2565	2569	2985		NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	195	405	416	936	1260	NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	642	858	951	1158		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	1359	1691	1769	2010		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	1960	2508	3118	3553		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	492	603	820	974		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	897	990	1160	1298		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	1345	1495	1522	1605		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	1665	2102	2323	2715		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	2110	2161	2696	2751		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	5	10	220	492		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	429	440	543	871		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	303	677	692	765		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	929	1000	1117	1310		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	1719	1759	1955	2013		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	2703	3261	3370	3991		NO SUSPENDED ITEMS
[illegible]	[illegible]	3	3	69	303	373			NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	25	191	341	469		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	690	738	765	895		NO SUSPENDED ITEMS
[illegible]	[illegible]	4	4	919	1384	1488	1660		NO SUSPENDED ITEMS
[illegible]	[illegible]	[illegible]	[illegible]	29	25	194	215	226	NO SUSPENDED ITEMS
				237	279	286			
4204	72 0000180A010	3	3	261	293	293			NO SUSPENDED ITEMS
4205	72 0000180A010	4	4	557	721	735	842		NO SUSPENDED ITEMS

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION		
4206	72	00001806010	8	8	1000	1000	1000	1245	1334	NO SUSPENDED ITEMS		
					1359	1629	2000					
4207	72	00001806010	4	4	1283	1710	1772	1904		NO SUSPENDED ITEMS		
4208	72	00001806010	7	7	10	51	987	2219	2298	NO SUSPENDED ITEMS		
					2641	3904						
4209	72	00001806010	8	8	6	8	8	10	1291	NO SUSPENDED ITEMS		
					1643	3098	3292					
4210	72	00001806010	5	5	118	1113	2045	2078	3335	NO SUSPENDED ITEMS		
4240	5	03102021010	3	3	1878100	2457600	2744100			NO SUSPENDED ITEMS		
4241	5	03102021010	3	3	2293800	4161700	7182700			NO SUSPENDED ITEMS		
4242	5	03102021010	4	4	2274000	5122700	5384600	6187000		18960400		
4243	6	03902028010	3	3	230000	1894000	7950060			NO SUSPENDED ITEMS		
4244	6	03902028010	3	3	6131000	13071000	23230003			NO SUSPENDED ITEMS		
4245	6	03902021010	2	2	2045000	5555000				NO SUSPENDED ITEMS		
4246	6	03902021010	2	2	2276000	7162000				NO SUSPENDED ITEMS		
4247	6	03902021010	5	4	2045000	7276000	5555000	7162000		23500000		
4248	7	03102021010	3	2	514900	1160500				3813200		
4250	7	03102021010	3	3	1968200	2180900	3963700			NO SUSPENDED ITEMS		
4252	7	03102021010	3	3	2080600	2505300	2674500			NO SUSPENDED ITEMS		
4253	7	03102021010	3	3	418300	4061900	4229100			NO SUSPENDED ITEMS		
4254	7	03102021010	2	2	17607000	19068100				NO SUSPENDED ITEMS		
4255	7	03102021010	4	4	563900	1185800	1274300	2542000		NO SUSPENDED ITEMS		
4256	7	03102021010	3	3	923800	1512100	2483100			NO SUSPENDED ITEMS		
4257	7	03102021010	3	2	1711400	5322100				5322100		
4258	7	03102021010	3	3	2222100	3378200	8151000			NO SUSPENDED ITEMS		
4259	7	03102021010	12	12	418300	746600	923800	979900	1512100	NO SUSPENDED ITEMS		
					1969200	2062000	2180500	2483100	3963700			
					4061900	4229100						
4260	7	03102021010	11	8	1711400	2125100	2222100	3378200	5322100	20000000	20000000	20000000
					8151000	12607000	19068100					
4267	2	03102021010	3	3	615000	1690000	2293000			NO SUSPENDED ITEMS		
4268	2	03102921010	4	4	1710000	1880000	2323000	2501000		NO SUSPENDED ITEMS		
4269	2	03102923010	2	2	1392000	3295000				NO SUSPENDED ITEMS		
4270	2	03102928010	3	2	3535000	6590000				1376000		
4271	2	03102928010	3	3	780000	1301000	1962000			NO SUSPENDED ITEMS		
4272	2	03102928010	3	3	1150000	1256000	1286000			NO SUSPENDED ITEMS		
4273	46	15601821010	3	3	4571000	6189000	7090000			NO SUSPENDED ITEMS		
4274	20	03102021010	10	10	1239000	1345000	1519000	1574000	1620000	NO SUSPENDED ITEMS		
					1883000	1954000	2602000	3967000	5847000			

LISTED NUMBERS OF CYCLES TO FAILURE AND CYCLES TO SUSPENSION OF TESTING WITHOUT FAILURE FOR ALL GROUPS IN THE DATA COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
4275	20	03102021010	10	10	3497000	3629000	3695000	3891000	4282000	NO SUSPENDED ITEMS
					4440000	7045000	17413000	48779000	57380000	
4276	73	03102021010	20	20	655000	774000	790000	830000	884000	NO SUSPENDED ITEMS
					906000	909000	930000	953000	1004000	
					1012000	1041000	1070000	1120000	1154000	
					1155000	1252000	1259000	1516000	1664000	
4277	73	03102021010	10	10	879000	879000	923000	963000	1087000	NO SUSPENDED ITEMS
					1090000	1100000	1196000	1272000	1367000	
4300	73	03102021060	10	10	67	70	87	91	95	NO SUSPENDED ITEMS
					96	102	103	124	140	
4301	73	03102021060	10	10	79	95	100	104	106	NO SUSPENDED ITEMS
					111	114	117	122	127	
4302	73	03102021060	10	10	76	78	81	90	97	NO SUSPENDED ITEMS
					107	113	115	119	120	
4303	73	03102021060	5	5	77	80	93	95	99	NO SUSPENDED ITEMS
4304	73	03102021060	10	10	63	67	68	73	87	NO SUSPENDED ITEMS
					94	96	96	116	124	
4305	73	03102021060	10	10	74	115	118	119	126	NO SUSPENDED ITEMS
					137	140	140	162	156	
4306	73	03102021060	10	10	65	72	81	88	96	NO SUSPENDED ITEMS
					96	98	115	125	133	
4307	73	03102021060	5	5	76	85	86	88	90	NO SUSPENDED ITEMS
4308	73	03102021070	10	10	94	110	114	115	117	NO SUSPENDED ITEMS
					121	130	140	145	153	
4309	73	03102021070	13	13	59	59	63	70	80	NO SUSPENDED ITEMS
					92	96	104	105	105	
					111	115	143			
4310	73	03102021070	10	10	65	67	68	71	72	NO SUSPENDED ITEMS
					73	74	94	95	140	
4311	73	03102021070	5	5	75	78	81	82	102	NO SUSPENDED ITEMS
4312	73	03102021070	10	10	80	88	89	91	95	NO SUSPENDED ITEMS
					102	109	139	143	160	
4313	73	03102021070	5	5	82	98	100	114	143	NO SUSPENDED ITEMS
4314	73	03102021070	10	10	68	78	88	92	96	NO SUSPENDED ITEMS
					96	97	109	110	111	
4315	73	03102021070	5	5	64	77	86	99	112	NO SUSPENDED ITEMS
4316	73	03102021080	10	10	81	111	118	121	121	NO SUSPENDED ITEMS
					130	133	153	161	196	
4317	73	03102021083	10	10	78	82	86	95	91	NO SUSPENDED ITEMS
					96	124	132	149	158	

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
4318	73	03142021000	10	10	87	88	114	119	119	NO SUSPENDED ITEMS
					121	128	136	155	159	
4319	73	03192021000	10	10	89	121	127	147	164	NO SUSPENDED ITEMS
					174	192	201	205	208	
4540	20	03102021010	7	7	8649000	11676000	12100000	13405000	14703000	NO SUSPENDED ITEMS
					15983000	16863000				
4541	20	03102021010	7	7	5606000	5608000	6057000	6507000	7464000	NO SUSPENDED ITEMS
					7796000	10638000				
4542	20	03102021010	7	7	6681000	7972000	7972000	8834000	9692000	NO SUSPENDED ITEMS
					12270000	19370000				
4543	20	03102021010	7	7	4313000	4691000	5555000	6849000	7236000	NO SUSPENDED ITEMS
					7339000	9013000				
4544	20	03102021010	7	7	11575000	12517000	14587000	17411000	20026000	NO SUSPENDED ITEMS
					22530000	31709000				
4545	20	03102021010	7	7	3572000	4693000	4755000	4755000	5619000	NO SUSPENDED ITEMS
					6328000	7784000				
4546	20	03102021010	7	7	27243000	28108000	30783000	36757000	38919000	NO SUSPENDED ITEMS
					38919000	45413000				
5300	31	00050008011	3	3	48000	61000	61600			NO SUSPENDED ITEMS
5301	31	00050009011	3	3	36400	45900	70400			NO SUSPENDED ITEMS
5302	31	00053083011	3	3	20000	38700	130000			NO SUSPENDED ITEMS
5303	31	00053083011	2	2	175400	800000				NO SUSPENDED ITEMS
5304	32	00050083011	3	3	86000	360500	360000			NO SUSPENDED ITEMS
5305	31	00050089010	3	3	53800	65800	67800			NO SUSPENDED ITEMS
5306	31	00053089010	3	3	31500	51600	58800			NO SUSPENDED ITEMS
5307	31	00050089010	3	3	54300	57400	82500			NO SUSPENDED ITEMS
5308	32	00050089010	3	3	99000	144400	190000			NO SUSPENDED ITEMS
5309	32	00050083010	3	3	99400	339600	343400			NO SUSPENDED ITEMS
5310	39	08402038000	2	2	177000	742000				NO SUSPENDED ITEMS
5311	61	00002087021	3	3	552000	881000	1192000			NO SUSPENDED ITEMS
5312	61	00002087021	4	4	241000	535000	670000	1120000		NO SUSPENDED ITEMS
5313	61	00002087021	7	7	670000	675000	964000	964000	985000	NO SUSPENDED ITEMS
					1192000	1468000				
5314	61	00002087020	5	5	774000	800000	975000	1041000	1930000	NO SUSPENDED ITEMS
5315	60	00002087020	2	2	3460	3560				NO SUSPENDED ITEMS
5316	60	00002087020	2	2	4692	6451				NO SUSPENDED ITEMS
5317	60	00002087020	2	2	5535	8136				NO SUSPENDED ITEMS
5318	60	00002087020	2	2	7113	13500				NO SUSPENDED ITEMS
5319	60	00002087020	2	2	7220	8463				NO SUSPENDED ITEMS
5320	60	00002087020	2	2	9900	11790				NO SUSPENDED ITEMS

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
5321	60	00002087020	4	4	23919	24006	35829	73613		NO SUSPENDED ITEMS
5322	60	00002087020	4	4	10752	29115	42122	77537		NO SUSPENDED ITEMS
5323	60	00002087020	2	2	95619	102730				NO SUSPENDED ITEMS
5324	60	00002087020	3	3	76606	149762	149762			NO SUSPENDED ITEMS
5325	60	00002087020	2	2	80581	150077				NO SUSPENDED ITEMS
5326	60	00002087020	4	4	21919	28970	69586	91909		NO SUSPENDED ITEMS
5327	60	00002087020	3	3	32665	47183	143605			NO SUSPENDED ITEMS
5328	60	00002087020	2	2	178702	201131				NO SUSPENDED ITEMS
5329	60	00002087020	2	2	225452	280495				NO SUSPENDED ITEMS
5330	62	00002081021	2	2	580978	864057				NO SUSPENDED ITEMS
5331	62	00002081021	2	2	1060001	1295581				NO SUSPENDED ITEMS
5332	62	00002081021	2	2	402753	1123647				NO SUSPENDED ITEMS
5333	62	00002081021	2	2	484000	609000				NO SUSPENDED ITEMS
5334	62	00002081021	2	2	211387	918469				NO SUSPENDED ITEMS
5335	62	00002081021	2	2	990200	961200				NO SUSPENDED ITEMS
5336	62	00002081021	2	2	518053	995000				NO SUSPENDED ITEMS
5337	62	00002081021	2	2	269265	290000				NO SUSPENDED ITEMS
5338	62	00002081021	2	2	164363	164563				NO SUSPENDED ITEMS
5339	62	00002081021	2	2	143070	14327C				NO SUSPENDED ITEMS
5340	62	00002081021	2	1	93712	152650				NO SUSPENDED ITEMS
5341	62	00002081021	2	2	78120	117961				NO SUSPENDED ITEMS
5342	62	00002081021	2	2	251799	282701				NO SUSPENDED ITEMS
5343	62	00002081021	2	2	170632	195536				NO SUSPENDED ITEMS
5344	62	00002081021	2	2	171271	171471				NO SUSPENDED ITEMS
5345	62	00002081021	2	2	227023	285000				NO SUSPENDED ITEMS
5346	62	00002081021	2	2	204469	238646				NO SUSPENDED ITEMS
5347	62	00002081021	3	3	73670	91400	93760			NO SUSPENDED ITEMS
5348	62	00002081021	3	3	42000	50500	82500			NO SUSPENDED ITEMS
5349	62	00002081021	2	2	39930	39830				NO SUSPENDED ITEMS
5350	62	00002081021	2	2	60275	76550				NO SUSPENDED ITEMS
5351	62	00002081021	2	2	56760	82200				NO SUSPENDED ITEMS
5352	63	00002081021	13	13	91700	169400	199500	212600	213300	NO SUSPENDED ITEMS
					281700	288700	290500	356700	392600	
					411400	579300	897700			
5353	63	00002081021	10	10	189900	219100	281700	482600	499500	NO SUSPENDED ITEMS
					694200	696700	751800	769000	813900	
5354	63	00002081020	10	10	298600	405200	942400	867600	776800	NO SUSPENDED ITEMS
					954700	926100	978900	1052906	1086500	
5355	65	00052087051	5	5	569829	594000	698796	698796	7967520	NO SUSPENDED ITEMS

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
5396	65	00052087050	6	6	719705	751096	907279	912317	924312	NO SUSPENDED ITEMS
					1146698					
5461	31	00050000011	2	2	944900	1396000				NO SUSPENDED ITEMS
5462	31	00050000011	2	2	1023900	1612200				NO SUSPENDED ITEMS
5463	32	00050000011	3	3	1275300	1680000	3292200			NO SUSPENDED ITEMS
5464	32	00050003011	4	4	1120000	1424900	3687300	3718500		NO SUSPENDED ITEMS
5465	31	00050009010	2	2	1040300	1534300				NO SUSPENDED ITEMS
5466	31	00050009010	3	3	1625600	1907100	4639200			NO SUSPENDED ITEMS
5467	31	00050009010	2	2	1531600	2701000				NO SUSPENDED ITEMS
5468	32	00050009010	3	3	1287900	1698400	3860200			NO SUSPENDED ITEMS
5469	32	00050003010	4	4	1160100	1859000	3710700	3729909		NO SUSPENDED ITEMS
5470	39	03202009090	2	2	6450000	23000000				NO SUSPENDED ITEMS
5471	61	00002087021	4	2	2520000	3670000				[illegible] [illegible]
5472	61	00002087020	2	2	3565000	4560000				NO SUSPENDED ITEMS
5473	61	00002087020	2	2	991000	1471000				NO SUSPENDED ITEMS
5474	60	00002087020	4	4	1969247	2335040	4004440	6265514		NO SUSPENDED ITEMS
5475	60	00002087020	4	4	553694	834034	1133707	2327100		NO SUSPENDED ITEMS
5476	60	00002087020	4	4	2275645	2567198	2740155	3162490		NO SUSPENDED ITEMS
5477	60	00002087020	2	2	2306842	5390400				NO SUSPENDED ITEMS
5478	60	00002087020	4	4	2983567	3006075	3990050	5140101		NO SUSPENDED ITEMS
5479	60	00002087020	4	4	1443195	3129757	3990050	4654378		NO SUSPENDED ITEMS
5480	60	00002087020	2	2	10491473	10551123				NO SUSPENDED ITEMS
5481	63	00002081021	13	13	232700	270000	530200	703600	724700	NO SUSPENDED ITEMS
					764400	1029200	1132500	1208600	1225400	
					1225400	1573000	1610703			
5482	63	00002081021	9	9	964100	1161900	1902200	1937700	2037100	NO SUSPENDED ITEMS
					2455000	3396400	3733300	4697700		
5483	63	00002081020	10	10	1274000	2005400	2133900	2211500	2511000	NO SUSPENDED ITEMS
					3511000	3012700	3861900	4434300	6496500	
5701	36	04002921011	3	3	102200	113000	151500			NO SUSPENDED ITEMS
5702	36	04002921010	3	3	114000	127600	159000			NO SUSPENDED ITEMS
5703	36	04002921010	3	3	61600	65300	862000			NO SUSPENDED ITEMS
5704	36	04002921011	3	3	49100	65200	107000			NO SUSPENDED ITEMS
5705	36	04002921010	3	3	66100	67000	100000			NO SUSPENDED ITEMS
5706	36	04002921011	3	3	55900	77000	99900			NO SUSPENDED ITEMS
5707	36	04002921010	3	3	58500	78200	96700			NO SUSPENDED ITEMS
5708	36	04002921011	4	4	172000	177900	226700	241300		NO SUSPENDED ITEMS
5709	36	04002921010	4	4	172000	178000	226700	241300		NO SUSPENDED ITEMS
5710	36	04002921011	4	4	104100	142600	217500	243000		NO SUSPENDED ITEMS
5711	36	04002921010	4	4	108200	142600	217500	243000		NO SUSPENDED ITEMS

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
5712	36	04002921011	4	4	137700	184200	239100	295800		NO SUSPENDED ITEMS
5713	36	04002921010	4	4	137700	208000	252000	299800		NO SUSPENDED ITEMS
5714	36	04002921011	4	4	63900	134800	204000	237600		NO SUSPENDED ITEMS
5715	36	04002921010	4	4	63900	137500	204000	375600		NO SUSPENDED ITEMS
5716	36	04002921011	3	3	180100	210400	276300			NO SUSPENDED ITEMS
5717	36	04002921010	3	3	189400	210400	281700			NO SUSPENDED ITEMS
5718	36	04002921011	3	3	46200	52200	75100			NO SUSPENDED ITEMS
5719	36	04002921010	3	3	46200	79100	92400			NO SUSPENDED ITEMS
5720	36	04002921011	3	3	106700	186000	213500			NO SUSPENDED ITEMS
5721	36	04002921010	3	3	123100	201500	225700			NO SUSPENDED ITEMS
5722	36	04002921011	3	3	45500	73800	277400			NO SUSPENDED ITEMS
5723	36	04002921010	3	3	62500	83600	279400			NO SUSPENDED ITEMS
5724	36	04002921011	5	5	41700	41400	118000	141600	215000*	NO SUSPENDED ITEMS
5725	36	04002921010	5	5	98400	106000	118000	159400	223300*	NO SUSPENDED ITEMS
5726	36	04002921011	5	5	111800	126000	143500	199400	214200*	NO SUSPENDED ITEMS
5727	36	04002921010	5	5	150400	180000	202000	224000	253500*	NO SUSPENDED ITEMS
5728	36	04002921011	5	5	92400	92900	107000	131300	139600*	NO SUSPENDED ITEMS
5729	36	04002921010	5	5	98400	102300	117200	131300	139600*	NO SUSPENDED ITEMS
5730	36	04002921011	5	5	70800	80600	103500	170100	258600*	NO SUSPENDED ITEMS
5731	36	04002921010	5	5	70800	80600	111000	180800	288700*	NO SUSPENDED ITEMS
5732	36	04002921011	3	3	63600	95900	121400			NO SUSPENDED ITEMS
5733	36	04002921010	3	3	64300	105000	128500			NO SUSPENDED ITEMS
5734	36	04002921011	3	3	59500	107600	117700			NO SUSPENDED ITEMS
5735	36	04002921010	3	3	62000	109400	122000			NO SUSPENDED ITEMS
5736	36	04002921011	3	3	17300	24300	66300			NO SUSPENDED ITEMS
5737	36	04002921011	3	3	37200	43700	73600			NO SUSPENDED ITEMS
5738	36	04002921011	3	3	41700	42500	42700			NO SUSPENDED ITEMS
5739	36	04002921010	3	3	42500	42700	45100			NO SUSPENDED ITEMS
5740	36	04002921011	4	4	58900	61000	65700	66900		NO SUSPENDED ITEMS
5741	36	04002921010	4	4	58900	61300	65700	69100		NO SUSPENDED ITEMS
5742	36	04002921011	3	3	38800	67300	104400			NO SUSPENDED ITEMS
5743	36	04002921010	3	3	43200	84000	131900			NO SUSPENDED ITEMS
5744	36	04002921011	4	4	13800	21700	36500	115300		NO SUSPENDED ITEMS
5745	36	04002921010	4	4	25500	27500	45900	142300		NO SUSPENDED ITEMS
5746	36	04002921011	4	4	16900	20100	21200	26400		NO SUSPENDED ITEMS
5747	36	04002921010	4	4	25000	25600	27500	37800		NO SUSPENDED ITEMS
5748	36	04002922011	3	3	64600	76400	127900			NO SUSPENDED ITEMS
5749	36	04002922010	3	3	64600	80000	139500			NO SUSPENDED ITEMS
5750	36	04002922011	4	4	21000	37500	47500	58300		NO SUSPENDED ITEMS
5751	36	04002922010	4	4	21000	37500	48200	58700		NO SUSPENDED ITEMS

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
5752	36	04002922011	4	4	42000	43500	53100	58200		NO SUSPENDED ITEMS
5753	36	04002922010	4	4	42000	44500	53100	58200		NO SUSPENDED ITEMS
5754	36	04002922011	4	4	33800	44800	48900	115300		NO SUSPENDED ITEMS
5755	36	04002922010	4	4	33800	49000	50300	116000		NO SUSPENDED ITEMS
5756	36	04002922011	4	4	49000	53200	99400	172200		NO SUSPENDED ITEMS
5757	36	04002922010	4	4	49800	54600	105700	172900		NO SUSPENDED ITEMS
5758	36	04002922011	4	4	48000	93700	128000	240300		NO SUSPENDED ITEMS
5759	36	04002922010	4	4	49700	96500	129200	240300		NO SUSPENDED ITEMS
5760	36	04002922011	4	4	39000	50400	100800	249000		NO SUSPENDED ITEMS
5761	36	04002922010	4	4	39000	50400	104300	250000		NO SUSPENDED ITEMS
5762	36	04002922011	3	3	24600	63000	65000			NO SUSPENDED ITEMS
5763	36	04002922010	3	3	24600	63000	68600			NO SUSPENDED ITEMS
5764	36	04002922011	3	3	54700	89600	116100			NO SUSPENDED ITEMS
5765	36	04002922010	3	3	54700	89600	116100			NO SUSPENDED ITEMS
5766	36	04002922011	3	3	102500	108900	133500			NO SUSPENDED ITEMS
5767	36	04002922010	3	3	102500	108900	133500			NO SUSPENDED ITEMS
5768	36	04002922011	3	3	97000	228700	245000			NO SUSPENDED ITEMS
5769	36	04002922010	3	3	97000	245000	245300			NO SUSPENDED ITEMS
5770	36	04002922011	4	4	49900	51400	55300	92400		NO SUSPENDED ITEMS
5771	36	04002922010	4	4	62300	69000	103600	685000		NO SUSPENDED ITEMS
5773	36	04002922011	4	4	77600	150400	196000	214400		NO SUSPENDED ITEMS
5774	36	04002922010	4	4	85500	212000	214400	268000		NO SUSPENDED ITEMS
5775	36	04002922011	3	3	66500	67700	121600			NO SUSPENDED ITEMS
5776	36	04002922010	3	3	73000	76500	127400			NO SUSPENDED ITEMS
5777	36	04002922011	3	3	127000	181000	274400			NO SUSPENDED ITEMS
5778	36	04002922010	3	3	129400	187400	274400			NO SUSPENDED ITEMS
5779	36	04002812011	4	4	18900	33200	39600	50500		NO SUSPENDED ITEMS
5780	36	04002812010	4	4	33200	37500	39600	50500		NO SUSPENDED ITEMS
5781	36	04002812011	9	9	28400	30600	33100	35100	50300	NO SUSPENDED ITEMS
					52200	68100	83500	96500		
5782	36	04002812010	9	9	33300	34000	35300	37100	52900	NO SUSPENDED ITEMS
					57200	70800	87100	96500		
5783	36	04002812011	10	10	34700	35000	37800	39700	42300	NO SUSPENDED ITEMS
					47600	47900	55800	65000	102200	
5784	36	04002812010	10	10	40300	42900	42600	44300	48300	NO SUSPENDED ITEMS
					52200	52700	55800	66000	102200	
5785	36	04002812011	3	3	58600	82900	136500			NO SUSPENDED ITEMS
5786	32	04002812010	3	3	47600	98000	142800			NO SUSPENDED ITEMS
5787	36	04002812011	4	4	167200	219000	233100	268600		NO SUSPENDED ITEMS
5788	36	04002812010	4	4	169500	224400	233100	270600		NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	FFF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
5699	36	04002812011	8	8	19600	24000	31500	40000	42400	NO SUSPENDED ITEMS
					58500	61000	72200			
5700	36	04002812010	8	8	21700	25300	31500	42600	46500	NO SUSPENDED ITEMS
					59100	61000	72200			
5701	36	04002812011	4	4	20300	23000	23100	27400		NO SUSPENDED ITEMS
5702	36	04002812010	4	4	21000	23000	23100	27400		NO SUSPENDED ITEMS
5703	36	04002812011	4	4	23000	46900	51400	93800		NO SUSPENDED ITEMS
5704	36	04002812010	4	4	23300	46800	51500	71200		NO SUSPENDED ITEMS
5705	36	04002812011	4	4	52500	73800	137300	172000		NO SUSPENDED ITEMS
5706	36	04002812010	4	4	70700	74500	158300	172000		NO SUSPENDED ITEMS
5707	36	04002812011	5	5	22700	25500	42000	45200	47600	NO SUSPENDED ITEMS
5708	36	04002812010	5	5	23500	26000	42500	45500	47600	NO SUSPENDED ITEMS
5709	36	04002812011	4	4	35500	40000	55000	70700		NO SUSPENDED ITEMS
5710	36	04002812010	4	4	62900	70700	75800	79500		NO SUSPENDED ITEMS
5711	32	04002812011	2	2	85500	100000				NO SUSPENDED ITEMS
5712	36	04002812010	2	2	89000	140000				NO SUSPENDED ITEMS
5120	11	13087965410	3	2	192000	21997900				20320200
5713	36	04002811010	7	7	51000	51000	61000	61000	64000	NO SUSPENDED ITEMS
					69000	74000				
5714	36	04002812010	8	8	58000	66000	67000	75000	81000	NO SUSPENDED ITEMS
					86000	89000	144000			
5715	36	04002811011	3	3	64900	71400	111200			NO SUSPENDED ITEMS
5716	36	04002811010	3	3	71400	79200	111200			NO SUSPENDED ITEMS
5717	36	04002811011	3	3	14100	28500	29200			NO SUSPENDED ITEMS
5718	36	04002811010	3	3	21600	36000	36300			NO SUSPENDED ITEMS
5719	36	04002811011	4	4	15500	17000	24400	27500		NO SUSPENDED ITEMS
5720	36	04002811010	4	4	23600	25100	33300	34200		NO SUSPENDED ITEMS
5721	36	04402821011	8	7	36300	44700	45400	50000	52500	50600
					55600	61700				
5722	36	04402821010	8	7	52500	60900	62400	63900	69500	50600
					70900	71200				
5723	36	04002821011	6	6	36300	44700	45400	50000	55600	NO SUSPENDED ITEMS
					61700					
5724	36	04002821010	6	6	60900	62400	63900	69500	70900	NO SUSPENDED ITEMS
					71200					
5725	36	04002811011	3	3	28000	32400	42700			NO SUSPENDED ITEMS
5726	36	04002811010	3	3	36000	36700	44900			NO SUSPENDED ITEMS
5727	36	04002811011	3	3	40700	41300	48500			NO SUSPENDED ITEMS
5728	36	04002811010	3	3	40700	41300	48500			NO SUSPENDED ITEMS
5729	36	04002811011	3	3	238400	241400	264600			NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND CYCLES TO SUSPENSION OF TESTING WITHOUT FAILURE FOR ALL GROUPS IN THE DATA COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
5733	36	0400281101?	3	3	238100	241400	264600			NO SUSPENDED ITEMS
5741	36	0400281101?	3	3	86700	87700	132000			NO SUSPENDED ITEMS
5742	36	0400281101?	3	3	86700	87700	132000			NO SUSPENDED ITEMS
5733	36	0400281201?	3	3	77400	92600	146000			NO SUSPENDED ITEMS
5734	36	0400281201?	3	3	92600	96700	146000			NO SUSPENDED ITEMS
5735	36	0400281201?	3	3	72300	116600	259900			NO SUSPENDED ITEMS
5736	36	0400281201?	3	3	72300	116600	259900			NO SUSPENDED ITEMS
5737	36	0400281201?	3	3	212000	251000	325000			NO SUSPENDED ITEMS
5738	36	0400281201?	6	6	197000	211000	231000	298000	332000	NO SUSPENDED ITEMS
					463300					
5739	36	0510201101?	2	2	47000	42000				NO SUSPENDED ITEMS
5740	36	0510201101?	3	3	91000	102000	169600			NO SUSPENDED ITEMS
5741	36	0510201101?	2	2	95000	140000				NO SUSPENDED ITEMS
5742	36	0510281101?	9	9	59000	62000	67000	69000	72000	NO SUSPENDED ITEMS
					73000	75000	76000	91000		
5743	36	0400281201?	4	4	61300	88300	102600	105700		NO SUSPENDED ITEMS
5744	36	0400281201?	4	4	71300	91000	102600	110800		NO SUSPENDED ITEMS
5820	36	0640282101?	4	2	472000	3391000				6049000 7261800
5822	36	0640282101?	4	2	3391000	4697900				6049000 7261000
5850	32	0000608301?	4	4	126000	265000	325000	400000		NO SUSPENDED ITEMS
5851	32	0000108301?	3	3	127600	370400	502000			NO SUSPENDED ITEMS
5852	32	0000108301?	4	4	263700	364400	360600	409000		NO SUSPENDED ITEMS
6000	9	064?386?810	20	20	34000	35000	36000	47000	48000	NO SUSPENDED ITEMS
					48000	52000	63000	77000	79000	
					89000	85000	92000	97000	105000	
					116000	117000	118000	125000	130000	
6001	9	064??360810	3	3	31850	33117	35050			NO SUSPENDED ITEMS
6002	9	064??360910	3	3	88667	114060	114833			NO SUSPENDED ITEMS
6003	9	064??360810	3	3	9567	9800	10733			NO SUSPENDED ITEMS
6004	9	064??360810	3	3	15230	17600	17800			NO SUSPENDED ITEMS
6005	9	064??360810	3	3	1033	3500	3967			NO SUSPENDED ITEMS
6006	9	064??360810	3	3	4600	5267	5750			NO SUSPENDED ITEMS
6007	11	1008?865410	3	3	352900	553700	4385300			NO SUSPENDED ITEMS
6008	11	1008?365410	2	2	205200	401100				NO SUSPENDED ITEMS
6009	11	1008?365410	2	2	99000	220800				NO SUSPENDED ITEMS
6010	11	1008?865410	2	2	45300	124400				NO SUSPENDED ITEMS
6011	11	1008?865460	2	2	48400	55400				NO SUSPENDED ITEMS
6012	11	1008?865410	2	2	13100	13201				NO SUSPENDED ITEMS
6013	11	1008?954110	2	2	77800	842700				NO SUSPENDED ITEMS
6014	11	1008?965410	2	2	91100	105000				NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
CYCLES TO SUSPENSION OF TESTING WITHOUT
FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
6015	11	10087965610	2	2	45100	55000				NO SUSPENDED ITEMS
6016	11	10047965610	2	2	24600	33500				NO SUSPENDED ITEMS
6017	11	10087965610	2	2	9600	12100				NO SUSPENDED ITEMS
6018	11	10039865610	2	2	170000	725000				NO SUSPENDED ITEMS
6019	11	10[illegible]65610	2	2	16400	17000				NO SUSPENDED ITEMS
6020	11	10089965610	2	2	118200	321700				NO SUSPENDED ITEMS
6122	11	10089865610	2	2	725700	1449400				NO SUSPENDED ITEMS
6300	10	05110865020	102	102	233000	258000	268000	276000	290000	NO SUSPENDED ITEMS
					310000	312000	315000	318000	321000	
					321000	329000	335000	336000	338000	
					338000	342000	342000	342000	344000	
					349000	350000	350000	351000	351000	
					352000	352000	356000	358000	358000	
					360000	362000	363000	366000	367000	
					370000	370000	372000	372000	374000	
					375000	376000	379000	379000	380000	
					382000	389000	389000	395000	396000	
					400000	400000	400000	403000	404000	
					406000	408000	408000	410000	417000	
					414000	416000	416000	416000	420000	
					422000	423000	426000	428000	432000	
					432000	433000	433000	437000	438000	
					439000	439000	443000	445000	445000	
					452000	456000	456000	460000	464000	
					466000	469000	470000	470000	473000	
					474000	476000	476000	486000	488000	
					489000	490000	491000	501000	517000	
					540000	560000				

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ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
6301	10	05108855020	101	101	70000	90000	96000	97000	99000	NO SUSPENDED ITEMS
					100000	103000	104000	104000	105000	
					107000	108000	108000	108000	109000	
					109000	112060	112000	113000	116000	
					114000	114000	116000	119000	120000	
					120000	120000	121000	121000	123000	
					124000	124000	124000	124000	126000	
					128000	128000	129000	129000	130000	
					130000	130000	131000	131000	131000	
					131000	131000	132000	132000	132000	
					133000	134000	134000	134000	134000	
					134000	136000	136000	137000	138000	
					138000	138000	139000	139000	141000	
					141000	142000	142000	142000	142000	
					142000	142000	144000	144000	145000	
					146000	148000	148000	149000	151000	
					151000	152000	155000	156000	137000	
					157000	157000	157000	159000	159000	
					162000	163000	163000	164000	166000	
					166000	168000	170000	174000	196000	
					212000					
6302	9	06333855810	9	9	237000	265000	271000	294000	304000	NO SUSPENDED ITEMS
					305000	314000	370000	396000		
6303	11	10087955410	2	2	469300	565300				NO SUSPENDED ITEMS
6304	11	10087955410	2	2	108100	150600				NO SUSPENDED ITEMS
6305	11	10087455410	2	2	45500	53500				NO SUSPENDED ITEMS
6306	11	10087955410	2	2	251500	309200				NO SUSPENDED ITEMS
6307	11	10087955410	2	2	68600	87600				NO SUSPENDED ITEMS
6308	11	10087955410	2	2	16800	32000				NO SUSPENDED ITEMS
6309	11	10089855410	2	2	563800	1011400				NO SUSPENDED ITEMS
6310	11	10089855410	2	2	96500	121000				NO SUSPENDED ITEMS
6311	11	10089855410	2	2	42800	49100				NO SUSPENDED ITEMS
6312	11	10089955410	2	2	46000	104500				NO SUSPENDED ITEMS
6313	11	10089955410	2	2	10000	11500				NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND CYCLES TO SUSPENSION OF TESTING WITHOUT FAILURE FOR ALL GROUPS IN THE DATA COLLECTION

[illegible]		[illegible]	SAMPLE TEST	SIZE FAIL	CYCLES AT FAILURE					CYCLES AT SUSPENSION
[illegible]	1[illegible]	[illegible]	101	101	670000	706000	716000	746000	765000	NO SUSPENDED ITEMS
					797000	844000	855000	858000	880000	
					886000	933000	960000	984000	990000	
					1000000	1010000	1016000	1018000	1020000	
					1055000	1085000	1102000	1107000	1108000	
					1115000	1120000	1134000	1140000	1199000	
					1200000	1200000	1203000	1222000	1235000	
					1238000	1252000	1254000	1267000	1269000	
					1270000	1290000	1293000	1300000	1310000	
					1313000	1315000	1330000	1355000	1390000	
					1416000	1419000	1420000	1420000	1450000	
					1457000	1475000	1478000	1491000	1485000	
					1502000	1505000	1513000	1522000	1522000	
					1530000	1540000	1560000	1567000	1578000	
					1594000	1602000	1604000	1604000	1630000	
					1642000	1674000	1730000	1750000	1750000	
					1765000	1768000	1781000	1782000	1792000	
					1820000	1868000	1881000	1890000	1893000	
					1895000	1910000	1923000	1940000	1945000	
					2023000	2100000	2130000	2215000	2269000	
					2440000					
6461	11	10097855410	2	2	7910800	9277100				NO SUSPENDED ITEMS
6462	11	10087955410	2	2	1893000	7771600				NO SUSPENDED ITEMS
6463	11	10083855410	2	2	6114700	7641900				NO SUSPENDED ITEMS
6464	11	10089955410	3	3	71300	1303900	21483300			NO SUSPENDED ITEMS
6500	12	12834819010	5	5	250	2600	13100	25600	51400	NO SUSPENDED ITEMS
6501	12	12834818010	3	3	13100	25600	51400			NO SUSPENDED ITEMS
6502	12	12834818010	3	3	93000	109000	151000			NO SUSPENDED ITEMS
6503	12	12834818010	2	2	250000	273000				NO SUSPENDED ITEMS
6504	12	12834818010	5	5	472000	498000	504000	655000	792000	NO SUSPENDED ITEMS
6505	12	12834818010	3	3	4800	32200	58000			NO SUSPENDED ITEMS
6506	12	12834819010	3	3	31600	67200	95400			NO SUSPENDED ITEMS
6507	12	12834918010	3	3	294000	330000	394000			NO SUSPENDED ITEMS
6508	12	12834818010	2	2	95000	110000				NO SUSPENDED ITEMS
6509	12	12834818010	3	3	237000	278000	355000			NO SUSPENDED ITEMS
6510	12	12833814010	2	2	9100	31900				NO SUSPENDED ITEMS
6511	12	12833818010	4	4	4100	22700	45900	119800		NO SUSPENDED ITEMS
6512	12	12833818010	3	3	28500	76400	448600			NO SUSPENDED ITEMS
6513	12	12833818010	4	4	98600	154400	197400	285500		NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
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COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
6514	12	12833818010	7	7	307000	542000	698000	813000	829000	NO SUSPENDED ITEMS
					954000	1003000				
6515	12	12833818010	2	2	48400	109200				NO SUSPENDED ITEMS
6516	12	12833818010	2	2	123400	232600				NO SUSPENDED ITEMS
6517	12	12833818010	2	2	384000	443000				NO SUSPENDED ITEMS
6518	12	12833818010	2	2	25200	95100				NO SUSPENDED ITEMS
6519	12	12833818010	2	2	260000	266000				NO SUSPENDED ITEMS
6520	12	12827818010	3	3	3000	9000	13700			NO SUSPENDED ITEMS
6521	12	12827818010	4	4	10200	14800	51000	57000		NO SUSPENDED ITEMS
6522	12	12827918010	3	3	124000	151000	153000			NO SUSPENDED ITEMS
6523	12	12827818010	4	4	157000	177000	183000	187000		NO SUSPENDED ITEMS
6524	12	12827818010	6	6	344000	418000	483003	559000	614000	NO SUSPENDED ITEMS
					809000					
6525	12	12827818010	4	4	8900	11100	26800	26900		NO SUSPENDED ITEMS
6526	12	12827818010	3	3	51600	56700	58403			NO SUSPENDED ITEMS
6527	12	12827818010	3	3	80200	94700	140200			NO SUSPENDED ITEMS
6528	12	12827818010	3	3	355000	409000	448003			NO SUSPENDED ITEMS
6529	12	12927818010	3	3	911000	911000	1005000			NO SUSPENDED ITEMS
6530	12	12827818010	2	2	176000	183000				NO SUSPENDED ITEMS
6531	12	12827818010	2	2	230000	281000				NO SUSPENDED ITEMS
6532	12	12834811013	3	3	8000	8200	8503			NO SUSPENDED ITEMS
6533	12	12834811010	3	3	18500	20000	21700			NO SUSPENDED ITEMS
6534	12	12834811010	3	3	26300	30900	35700			NO SUSPENDED ITEMS
6535	12	12834811010	3	3	69400	72300	80600			NO SUSPENDED ITEMS
6536	12	12834811010	3	3	161000	187000	357000			NO SUSPENDED ITEMS
6537	12	12834811010	4	4	357000	659000	700000	1264000		NO SUSPENDED ITEMS
6538	12	12834811010	2	2	14800	19000				NO SUSPENDED ITEMS
6539	12	12834811010	2	2	28700	33100				NO SUSPENDED ITEMS
6540	12	12834811010	2	2	68300	81200				NO SUSPENDED ITEMS
6541	12	12834811010	2	2	203000	250000				NO SUSPENDED ITEMS
6542	12	12834811010	2	2	11600	12700				NO SUSPENDED ITEMS
6543	12	12834811010	2	2	30900	36900				NO SUSPENDED ITEMS
6544	12	12833811010	2	2	87800	93000				NO SUSPENDED ITEMS
6545	12	12833811010	2	2	13500	14600				NO SUSPENDED ITEMS
6546	12	12833811010	2	2	21500	37000				NO SUSPENDED ITEMS
6547	12	12833811010	2	2	75500	115000				NO SUSPENDED ITEMS
6548	12	12833811010	2	2	120000	161800				NO SUSPENDED ITEMS
6549	12	12833811010	2	2	13000	16500				NO SUSPENDED ITEMS
6550	12	12833811010	2	2	25900	28100				NO SUSPENDED ITEMS
6551	12	12833811010	2	2	40900	70000				NO SUSPENDED ITEMS

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COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
6552	12	12833811010	2	2	241000	241000				NO SUSPENDED ITEMS
6553	12	12827811010	3	3	10800	11200	13800			NO SUSPENDED ITEMS
6554	12	12827811010	3	3	17200	20200	25800			NO SUSPENDED ITEMS
6555	12	12827811010	3	3	32400	37600	43600			NO SUSPENDED ITEMS
6556	12	12827811010	3	3	51400	58200	87600			NO SUSPENDED ITEMS
6557	12	12827811010	3	3	130500	165600	321600			NO SUSPENDED ITEMS
6558	12	12827811010	3	3	7700	8300	8400			NO SUSPENDED ITEMS
6559	12	12827811010	4	4	14500	16200	16400	19500		NO SUSPENDED ITEMS
6560	12	12827811010	2	2	23000	31100				NO SUSPENDED ITEMS
6561	12	12827811010	3	3	94300	98200	135900			NO SUSPENDED ITEMS
6562	12	12827811010	2	2	8500	8501				NO SUSPENDED ITEMS
6563	12	12827811010	3	3	11900	14600	17700			NO SUSPENDED ITEMS
6564	12	12827811010	3	3	36700	40500	62400			NO SUSPENDED ITEMS
6565	12	12834811010	2	2	10300	12700				NO SUSPENDED ITEMS
6566	12	12834811010	2	2	23500	45200				NO SUSPENDED ITEMS
6567	12	12834811010	2	2	57200	212500				NO SUSPENDED ITEMS
6568	12	12834811010	2	2	335000	1273000				NO SUSPENDED ITEMS
6569	12	12834811010	2	2	47000	93700				NO SUSPENDED ITEMS
6570	12	12834811010	2	2	378400	378401				NO SUSPENDED ITEMS
6571	12	12827811010	2	2	10400	13900				NO SUSPENDED ITEMS
6572	12	12827811010	2	2	29200	54200				NO SUSPENDED ITEMS
6573	12	12827811010	2	2	73300	113700				NO SUSPENDED ITEMS
6574	12	12827811010	2	2	222000	652000				NO SUSPENDED ITEMS
6575	12	12827811010	2	2	12700	13600				NO SUSPENDED ITEMS
6576	12	12827811010	2	2	19200	26100				NO SUSPENDED ITEMS
6577	12	12827811010	2	2	57500	109600				NO SUSPENDED ITEMS
6582	71	08050833010	4	4	591210	633900	644730	721990		NO SUSPENDED ITEMS
6583	71	08050833010	3	3	14271	22926	26750			NO SUSPENDED ITEMS
6660	12	12834818010	3	3	2021000	3400000	4075000			NO SUSPENDED ITEMS
6661	12	12834818010	4	4	1610000	1796000	1972000	4000000		NO SUSPENDED ITEMS
6662	12	12833818010	2	2	1200000	1206000				NO SUSPENDED ITEMS
6663	12	12833818010	2	2	1924000	3361000				NO SUSPENDED ITEMS
6664	12	12827818010	3	3	570000	1330000	4500000			NO SUSPENDED ITEMS
6665	12	12827818010	4	2	964000	1321000				4556000 15000000
6666	12	12827818010	2	2	1693000	2093000				NO SUSPENDED ITEMS
6667	12	12833811010	2	2	1658000	3800000				NO SUSPENDED ITEMS
6669	12	12834811010	2	2	1165000	1462000				NO SUSPENDED ITEMS
6670	12	12827811010	2	2	3425000	5471000				NO SUSPENDED ITEMS
6700	71	08050833070	5	5	434	539	708	1075	12270	NO SUSPENDED ITEMS
6701	71	08050833070	5	5	168	207	236	274	2964	NO SUSPENDED ITEMS

LISTED NUMBERS OF CYCLES TO FAILURE AND
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FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	REF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE					CYCLES AT SUSPENSION
6702	71	08050833070	3	3	194	215	230			NO SUSPENDED ITEMS
6703	71	08050833080	3	3	219	264	274			NO SUSPENDED ITEMS
6900	9	34031806410	3	3	82000	100000	139000			NO SUSPENDED ITEMS
6901	9	40032806410	3	3	9200	10600	12600			NO SUSPENDED ITEMS
6902	9	40032806410	4	4	120000	126000	127000	165000		NO SUSPENDED ITEMS
6903	9	40032806410	2	2	88200	136000				NO SUSPENDED ITEMS
6904	9	40032806410	2	2	202000	236000				NO SUSPENDED ITEMS
6905	9	40032806410	3	3	462000	491000	513000			NO SUSPENDED ITEMS
6906	9	40032806410	2	2	547000	643000				NO SUSPENDED ITEMS
6907	9	03232960810	2	2	181000	462000				NO SUSPENDED ITEMS
6908	9	03031060410	5	4	143000	192000	201000	712000		917000
6909	9	03031060410	3	3	95000	95000	108000			NO SUSPENDED ITEMS
6910	9	03031060410	3	3	78000	102000	120000			NO SUSPENDED ITEMS
7000	50	30022830410	4	4	215000	440000	1030000	1276000		NO SUSPENDED ITEMS
7001	50	30022860410	5	5	97000	297000	340000	516000	609000	NO SUSPENDED ITEMS
7002	50	30022960410	3	3	94000	177000	272000			NO SUSPENDED ITEMS
7003	50	30022960410	5	4	74000	172000	192000	377000		160000
7004	51	30022860410	5	5	59000	67000	67000	77000	82000	NO SUSPENDED ITEMS
7005	51	30022860410	7	7	55000	55000	59000	63000	64000	NO SUSPENDED ITEMS
					65000	76000				
7006	51	30022960410	4	4	40000	46000	71000	95000		NO SUSPENDED ITEMS
7007	51	30022960410	8	8	52000	54000	64000	67000	71000	NO SUSPENDED ITEMS
					92000	119000	136000			
7008	52	30022960410	5	5	35000	38000	43000	53000	61000	NO SUSPENDED ITEMS
7009	55	20020860410	2	2	68000	104000				NO SUSPENDED ITEMS
7010	55	20020860110	2	2	85000	106000				NO SUSPENDED ITEMS
7011	55	20020860110	2	2	282000	543000				NO SUSPENDED ITEMS
7012	55	20020860110	2	2	86000	109000				NO SUSPENDED ITEMS
7013	55	20020860110	2	2	86000	109000				NO SUSPENDED ITEMS
7014	55	30020860410	2	2	161000	230000				NO SUSPENDED ITEMS
7015	55	30020860110	2	2	226000	476000				NO SUSPENDED ITEMS
7016	55	30020860110	2	2	131000	280000				NO SUSPENDED ITEMS
7017	55	30020860010	2	2	345000	1030000				NO SUSPENDED ITEMS
7018	56	20020860410	5	5	22000	22000	22000	24000	25000	NO SUSPENDED ITEMS
7019	56	20020960410	5	5	37000	38000	45000	51000	54000	NO SUSPENDED ITEMS
7020	56	20020860410	2	2	68000	104000				NO SUSPENDED ITEMS
7021	56	20020860410	5	5	171000	205000	317000	472000	1247000	NO SUSPENDED ITEMS
7022	56	20020860110	2	2	85000	104000				NO SUSPENDED ITEMS
7023	56	20020860110	2	2	282000	543000				NO SUSPENDED ITEMS
7000	56	20020860110	2	2	126000	244000				NO SUSPENDED ITEMS

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FAILURE FOR ALL GROUPS IN THE DATA
COLLECTION

ITEM	EFF	DESCRIPTION	SAMPLE SIZE	NUMBER FAILED	CYCLES AT FAILURE			CYCLES AT SUSPENSION
7001	56	20020860110	2	2	271000	344000		NO SUSPENDED ITEMS
7002	56	30020860410	4	3	36000	51000	53000	NO SUSPENDED ITEMS
7003	56	30020860410	4	3	161000	230000	287000	2864000
7004	56	30020860110	2	2	52000	70000		NO SUSPENDED ITEMS
7005	56	30020860110	3	2	226000	476000		1141000
7006	56	30020860110	2	2	61000	80000		NO SUSPENDED ITEMS
7007	56	30020960110	2	2	345000	1038000		NO SUSPENDED ITEMS
7069	54	20020855110	2	2	19000	22000		NO SUSPENDED ITEMS
7070	54	20020855110	2	2	32000	126000		NO SUSPENDED ITEMS
7071	54	20020855110	2	2	57000	69000		NO SUSPENDED ITEMS
7072	54	20020855110	2	2	75000	219000		NO SUSPENDED ITEMS
7073	54	30020855410	2	2	24000	45000		NO SUSPENDED ITEMS
7074	54	30020855410	2	2	130000	191000		NO SUSPENDED ITEMS
7100	41	16020871410	3	3	13000	14000	17000	NO SUSPENDED ITEMS
7101	41	16020821410	3	3	28000	34000	34000	NO SUSPENDED ITEMS
7102	41	16020821410	3	3	43000	45000	47000	NO SUSPENDED ITEMS
7103	41	16020811410	2	2	54000	69000		NO SUSPENDED ITEMS
7104	43	16020821010	2	2	16000	22000		NO SUSPENDED ITEMS
7105	43	16020821010	3	3	284000	340000	345000	NO SUSPENDED ITEMS
7106	43	16020821010	2	2	39000	39001		NO SUSPENDED ITEMS
7107	43	16020821010	3	3	244000	394000	1547000	NO SUSPENDED ITEMS
7108	43	16020821010	2	2	30000	62000		NO SUSPENDED ITEMS
7109	44	16020821010	3	3	24000	25000	36000	NO SUSPENDED ITEMS
7110	44	16020821010	2	2	543000	689000		NO SUSPENDED ITEMS
7111	44	16020821010	3	3	23000	36000	39000	NO SUSPENDED ITEMS
7112	44	16020821010	2	2	217000	573000		NO SUSPENDED ITEMS
7113	44	16020821010	3	3	20000	25000	27000	NO SUSPENDED ITEMS
7114	44	16020821010	3	3	303000	422000	782000	NO SUSPENDED ITEMS
7115	44	16020821010	3	3	38000	51000	52000	NO SUSPENDED ITEMS
7116	44	16020821010	3	3	235000	450000	625000	NO SUSPENDED ITEMS
7117	44	16020821010	3	3	41000	46000	51000	NO SUSPENDED ITEMS
7118	44	16020810100	3	2	417000	748000		1000000
7119	44	16020821010	3	3	24000	27000	27000	NO SUSPENDED ITEMS
7120	44	16020821010	2	2	332000	392000		NO SUSPENDED ITEMS
7121	44	16020821010	3	3	31000	32000	40000	NO SUSPENDED ITEMS
7122	44	16020821010	3	3	203000	332000	792000	NO SUSPENDED ITEMS
7123	44	16020821010	3	3	4000	5000	5000	NO SUSPENDED ITEMS
7124	44	16020821010	3	3	44000	45000	53000	NO SUSPENDED ITEMS
7125	44	16020821010	3	3	33000	45000	51000	NO SUSPENDED ITEMS
7126	44	16020821010	3	3	467000	490000	501000	NO SUSPENDED ITEMS

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7127	44	16020821010	3	3	18000	24000	43000			NO SUSPENDED ITEMS
7128	44	16020821010	3	3	212000	234000	1361000			NO SUSPENDED ITEMS
7129	44	16020821010	3	3	14000	15000	15000			NO SUSPENDED ITEMS
7130	45	16020821010	3	3	217000	495000	573000			NO SUSPENDED ITEMS
7131	45	16020821010	3	3	24000	27000	32000			NO SUSPENDED ITEMS
7132	45	16020821010	3	3	387000	451000	486000			NO SUSPENDED ITEMS
7133	45	16020821010	3	3	34000	35000	37000			NO SUSPENDED ITEMS
7134	45	16020821010	2	2	300000	356000				NO SUSPENDED ITEMS
7135	46	17020821010	4	4	16000	19000	25000	30000		NO SUSPENDED ITEMS
7136	46	16020821010	3	3	188000	356000	1086000			NO SUSPENDED ITEMS
7137	46	16020821010	4	4	11000	15000	17000	20000		NO SUSPENDED ITEMS
7138	46	17020821010	4	4	26000	27000	29000	30000		NO SUSPENDED ITEMS
7139	46	17020821010	4	4	24000	26000	29000	31000		NO SUSPENDED ITEMS
7140	47	16020821010	3	3	43000	43000	44000			NO SUSPENDED ITEMS
7141	47	16020821010	3	3	539000	549000	771000			NO SUSPENDED ITEMS
7142	47	16020821010	3	3	41000	54000	75000			NO SUSPENDED ITEMS
7143	47	16020831010	4	4	45000	76000	89000	90000		NO SUSPENDED ITEMS
7144	53	26020831110	2	2	31000	36000				NO SUSPENDED ITEMS
7145	53	26020831110	4	4	31000	36000	42000	43000		NO SUSPENDED ITEMS
7146	53	26020831410	4	4	22000	23000	28000	35000		NO SUSPENDED ITEMS
7147	53	31022831410	2	2	11000	36000				NO SUSPENDED ITEMS
7148	53	26020831110	5	5	94000	98000	170000	183000	352000	NO SUSPENDED ITEMS
7149	53	26020831410	4	4	129000	198000	235000	296000		NO SUSPENDED ITEMS
7150	53	31022831410	4	4	48000	110000	114000	145000		NO SUSPENDED ITEMS
7151	53	26020831410	2	2	745000	791000				NO SUSPENDED ITEMS
7152	53	31022831410	3	3	277000	330000	629000			NO SUSPENDED ITEMS
7260	43	16020821010	3	3	1091000	1702000	2720000			NO SUSPENDED ITEMS
7261	47	16020821010	3	3	1306000	1722000	1775000			NO SUSPENDED ITEMS
7262	47	16028310160	3	2	1551000	3592000				10380000
7263	53	26020831110	3	3	585000	1196000	3925000			NO SUSPENDED ITEMS
7600	31	00050089011	2	2	31500	48300				NO SUSPENDED ITEMS
7601	31	00053087011	3	3	850370	915230	936850			NO SUSPENDED ITEMS
7602	32	00052081011	3	3	441100	547300	588000			NO SUSPENDED ITEMS
7603	31	00054083010	3	3	36600	50000	69200			NO SUSPENDED ITEMS
7604	31	00053089010	4	4	73000	84100	104600	106500		NO SUSPENDED ITEMS
7605	31	00053083010	3	3	39400	59800	181500			NO SUSPENDED ITEMS
7606	31	00059081010	2	2	15830	28490				NO SUSPENDED ITEMS
7607	31	00059081010	2	2	103900	109860				NO SUSPENDED ITEMS
7608	31	00053087010	2	2	1446000	1460100				NO SUSPENDED ITEMS
7609	31	00053081010	3	3	1559000	1699100	1751400			NO SUSPENDED ITEMS

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7610	32	00054081010	3	3	513000	686700	918400			NO SUSPENDED ITEMS
7611	49	00050087020	41	41	88400	108560	108592	112208	118192	NO SUSPENDED ITEMS
					121552	122080	123088	130768	131600	
					132912	137296	138560	141376	142464	
					144608	148144	150016	152752	153168	
					154000	155200	158320	158400	160064	
					162352	165824	166528	166624	167744	
					175104	176608	177408	177552	178752	
					183376	189328	190128	190192	214752	
					245552					
7612	64	00050081020	3	3	2901	4239	4284			NO SUSPENDED ITEMS
7613	64	00050081020	2	2	1889	3430				NO SUSPENDED ITEMS
7721	31	00059081010	2	2	2110	2160				NO SUSPENDED ITEMS
7722	64	00050081021	2	2	1738	1998				NO SUSPENDED ITEMS
7723	64	00050081020	2	2	696	1272				NO SUSPENDED ITEMS
7761	31	00050089011	3	3	1219200	1564300	4600000			NO SUSPENDED ITEMS
7762	31	00053089010	4	4	373600	1749400	1857100	2052900		NO SUSPENDED ITEMS
7763	39	00050089090	2	2	147000	4140000				NO SUSPENDED ITEMS
7764	39	00050089090	2	2	562000	4950000				NO SUSPENDED ITEMS
7821	32	00056089011	2	2	1160	1230				NO SUSPENDED ITEMS
7822	31	00059083010	2	2	796	1012				NO SUSPENDED ITEMS
7823	31	00059083010	2	2	725	1384				NO SUSPENDED ITEMS
8000	31	00053081011	3	3	481300	971400	1460000			NO SUSPENDED ITEMS
8001	31	00053091010	3	3	130000	195100	216800			NO SUSPENDED ITEMS
8002	36	05150717010	7	7	36000	40000	41000	43000	44000	NO SUSPENDED ITEMS
					45000	46000				
8003	36	05150821010	4	4	41000	47000	51000	72000		NO SUSPENDED ITEMS
8004	36	05150821010	3	3	22000	25000	36000			NO SUSPENDED ITEMS
8005	36	05150811010	4	4	53000	57000	84000	113000		NO SUSPENDED ITEMS
8006	36	05150911010	4	4	25000	26000	32000	51000		NO SUSPENDED ITEMS
8121	31	00053081010	3	3	895900	1468100	2156000			NO SUSPENDED ITEMS
8122	36	05150821010	3	2	1461000	2456000				4431000
8123	36	05150811010	2	2	2009000	2554000				NO SUSPENDED ITEMS
8150	70	00050087020	2	2	315000	323000				NO SUSPENDED ITEMS
8151	70	00050087020	2	2	54000	65000				NO SUSPENDED ITEMS
8300	31	00058087011	3	3	136200	142700	247700			NO SUSPENDED ITEMS
8301	31	00058087011	3	3	396800	424800	450000			NO SUSPENDED ITEMS
8302	31	00059091011	3	3	13437	26318	27585			NO SUSPENDED ITEMS
8303	31	00058083011	3	3	73500	273300	792000			NO SUSPENDED ITEMS
8304	31	00058083011	3	3	11700	13300	20100			NO SUSPENDED ITEMS

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8305	31	00059097011	2	2	39700	39800				NO SUSPENDED ITEMS
8306	31	00059087011	2	2	335600	793600				NO SUSPENDED ITEMS
8307	32	00058087011	2	2	22900	61800				NO SUSPENDED ITEMS
8308	32	00059081011	2	2	31600	35100				NO SUSPENDED ITEMS
8309	32	00059081011	5	5	19400	22000	22300	26900	29400	NO SUSPENDED ITEMS
8310	32	00058087011	2	2	13000	15770				NO SUSPENDED ITEMS
8311	32	00058083011	2	2	13000	13840				NO SUSPENDED ITEMS
8312	31	00058087010	2	2	587200	967000				NO SUSPENDED ITEMS
8313	31	00058083010	3	3	273506	281000	1511400			NO SUSPENDED ITEMS
8314	31	00058083010	3	3	25100	25400	48100			NO SUSPENDED ITEMS
8315	31	00059087010	2	2	54300	56100				NO SUSPENDED ITEMS
8316	31	00059087010	3	3	379600	424000	865400			NO SUSPENDED ITEMS
8317	32	00059081010	2	2	47600	49500				NO SUSPENDED ITEMS
8318	32	00058087010	2	2	8230	12410				NO SUSPENDED ITEMS
8319	32	00058083010	2	2	13000	13930				NO SUSPENDED ITEMS
8320	33	00020083010	3	3	166000	172000	193000			NO SUSPENDED ITEMS
8321	33	00020083010	3	3	254000	456000	582000			NO SUSPENDED ITEMS
8322	33	00020083010	6	6	115000	130000	173000	178000	194000	NO SUSPENDED ITEMS
					212000					
8323	34	00059087011	3	3	23900	29700	35800			NO SUSPENDED ITEMS
8324	34	00059087011	6	6	31800	32600	37700	42900	49800	NO SUSPENDED ITEMS
					50700					
8325	34	00059087010	4	4	35500	38100	54900	56100		NO SUSPENDED ITEMS
8326	35	16050083010	4	4	16000	27000	58000	59000		NO SUSPENDED ITEMS
8327	35	16050083010	4	4	19000	20000	21000	23000		NO SUSPENDED ITEMS
8328	35	16050083010	4	4	9000	15000	17000	18000		NO SUSPENDED ITEMS
8329	35	16050083010	4	4	23000	27000	35000	39000		NO SUSPENDED ITEMS
8330	35	16050083010	5	5	11000	14000	14000	15000	29000	NO SUSPENDED ITEMS
8331	35	16050083010	5	5	19000	25000	29000	30000	38000	NO SUSPENDED ITEMS
8332	35	16050083010	4	4	10000	14000	22000	23000		NO SUSPENDED ITEMS
8333	35	16050083010	4	4	30000	33000	34000	83000		NO SUSPENDED ITEMS
8334	35	16050083010	3	3	168000	304000	441000			NO SUSPENDED ITEMS
8335	35	16050083010	3	3	223000	225000	240000			NO SUSPENDED ITEMS
8336	35	16050083010	4	4	10000	11000	12000	13000		NO SUSPENDED ITEMS
8337	35	16050083010	4	4	37000	44000	45000	45000		NO SUSPENDED ITEMS
8338	35	16050083010	3	3	83000	108000	138000			NO SUSPENDED ITEMS
8339	35	16050083010	4	4	188000	263000	265000	355000		NO SUSPENDED ITEMS
8340	35	16050083010	4	4	104000	110000	114000	126000		NO SUSPENDED ITEMS
8341	35	16050083010	4	4	309000	362000	372000	409000		NO SUSPENDED ITEMS
8342	35	16050083010	2	2	27000	31000				NO SUSPENDED ITEMS

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8343	35	16050083010	3	3	81000	84000	88000			NO SUSPENDED ITEMS
8344	35	16050083010	4	4	229000	250000	260000	269000		NO SUSPENDED ITEMS
8345	35	16050083010	2	2	33000	56000				NO SUSPENDED ITEMS
8346	35	16050083010	2	2	103000	198000				NO SUSPENDED ITEMS
8347	35	16050083010	2	2	68000	114000				NO SUSPENDED ITEMS
8348	35	16050083010	4	4	18000	28000	26000	35000		NO SUSPENDED ITEMS
8349	35	16050083010	4	4	59000	105000	106000	108000		NO SUSPENDED ITEMS
8350	35	16050083010	4	4	92000	141000	162000	648000		NO SUSPENDED ITEMS
8351	35	16050083010	4	4	39000	41000	55000	60000		NO SUSPENDED ITEMS
8352	35	16050083010	4	4	141000	141000	277000	315000		NO SUSPENDED ITEMS
8353	35	16050083010	3	3	240000	901000	949000			NO SUSPENDED ITEMS
8354	35	16050083010	4	4	189000	192000	221000	242000		NO SUSPENDED ITEMS
8355	38	16020073010	5	5	22000	28000	29000	45000	50000	NO SUSPENDED ITEMS
8356	38	16020073010	5	5	475000	497000	516000	637000	3949000	NO SUSPENDED ITEMS
8357	38	16020073010	5	5	61000	64000	69000	91000	95000	NO SUSPENDED ITEMS
8421	31	00058083011	3	3	136	234	662			NO SUSPENDED ITEMS
8422	32	00058087011	3	3	3200	5120	6010			NO SUSPENDED ITEMS
8423	32	00058087011	3	3	1290	1600	2970			NO SUSPENDED ITEMS
8424	31	00058083010	3	3	670	680	1010			NO SUSPENDED ITEMS
8425	32	00058083010	2	2	8090	9900				NO SUSPENDED ITEMS
8426	32	00058087010	2	2	2510	3870				NO SUSPENDED ITEMS
8427	35	16050083010	2	2	6000	7000				NO SUSPENDED ITEMS
8461	33	00020083010	3	3	699000	4436000	6330000			NO SUSPENDED ITEMS
8462	34	00059087011	3	3	760000	1178000	1339500			NO SUSPENDED ITEMS
8463	34	00059008709	2	2	826000	1370000				NO SUSPENDED ITEMS
8621	31	00059083011	5	5	660	790	807	845	9000	NO SUSPENDED ITEMS
21	1	04010860010	5	5	10800	12600	12960	14250	17280	NO SUSPENDED ITEMS

REFERENCES

(1) K.D. Raithby: "A Comparison of Predicted and Achieved Fatigue Lives of Aircraft Structures," Proceedings of Symposium on Fatigue of Aircraft Structures, Paris, 1961; MacMillan Co., New York, 1963

(2) H.M. Wells, Jr.: Air Force Structural Integrity Program Requirements, ASD-TR-66-57, January 1968

(3) A.M. Fruedenthal, "Reliability Analysis Based on Time to the First Failure," Conference Paper Presented at the Fifth I.C.A.F. Symposium, Melbourne, Australia, May 22-24, 1967

(4) A.M. Freudenthal, H. Itagaki, and M. Shinozuka: Time to First Failure for Various Distributions of Time to Failure, Technical Report AFML-TR-66-241, July 1966

(5) A.M. Freudenthal: The Expected Time to First Failure, Technical Report AFML-TR-66-37, November 1965

(6) A.M. Freudenthal: "The Material Aspect of Reliability," Structural Fatigue in Aircraft, ASTM STP 404, 1966

(7) A.M. Freudenthal: Fatigue Sensitivity and Reliability of Mechanical Systems, Especially Aircraft Structures, WADD Technical Report 611-53, July 1961

(8) A.M. Freudenthal and A.O. Payne: The Structural Reliability of Airframes, Technical Report AFML-TR-64-601, December 1964

(9) M. Shinozuka: Structural Reliability Under Conditions of Fatigue and Ultimate Load Failure, Technical Report AFML-TR-68-234, August 1968

(10) MIL-HDBK-5A, Metallic Materials and Elements for Aerospace Vehicle Structures, Department of Defense, Washington, D.C., February 1966

(11) E.J. Gumbel: Statistics of Extremes, Columbia University Press, New York, 1958

(12) S.R. Swanson: "Random Load Fatigue Testing: State-of-the-Art Survey," Materials Research and Standards, April 1968

(13) A.C. Cohen: "Maximum Likelihood Estimation in the Weibull Distribution Based on Complete and Censored Samples," Technometrics 7, 1965, pp. 579-88

(14) W. Weibull: Scatter of Fatigue Life and Fatigue Strength in Aircraft Structural Materials and Parts, FFA Report No. 73, 1957

(15) W. Weibull: Static Strength and Fatigue Properties of Threaded Bolts, FFA Report No. 59, 1955

(16) N.R. Mann: "Point and Interval Estimates for Reliability Parameters When Failure Times Have the Two-Parameter Weibull Distribution," Unpublished Doctoral Dissertation, University of California at Los Angeles, 1965

(17) N.R. Mann: "Tables for Obtaining the Best Linear Invariant Estimates of Parameters of the Weibull Distribution," Technometrics 9, November 1967, pp. 629-45

(18) N.R. Mann: "Point and Interval Estimation Procedures for the Two-Parameter Weibull and Extreme-Value Distributions," Technometrics 10, May 1968, pp. 231-76

(19) E.C. Naumann: Variable-Amplitude Fatigue Tests With Particular Attention to the Effects of High and Low Loads, NASA Technical Note D-1522, December 1962

(20) E.C. Naumann: Evaluation of the Influence of Load Randomization and of Ground-Air-Ground Cycles on Fatigue Life, NASA Technical Note D-1584, October 1964

( ) E.C. Naumann: Fatigue Under Random and Program Loads, NASA Technical Note D-2629, February 1965

( ) J. Schijve and F.A. Jacobs: Research on Cumulative Damage in Fatigue of Riveted Aluminum Alloy Joints, N.L.L. Report M.1999, January 1956

(23) J. Schijve and F.A. Jacobs: Program-Fatigue Tests on Notched Light Alloy Specimens of 2024 and 7075 Material, NLL-TR M.2070, 1960

(24) A.S. Tetelman and A.J. McEvily, Jr.: Fracture of Structural Materials, Part Four, John Wiley & Sons, Inc., 1967

(25) E.M. Perry and J.F. Rievley: Structural Flight Loads Data From Jet Tanker Operations, WADD-TN61-39, 1961

(26) A.C. Cohen: "Progressively Censored Samples in Life Testing," Technometrics 5, August 1963, pp. 327-39

(27) A. Hald: Statistical Theory With Engineering Applications, New York, John Wiley & Sons, Inc., 1952

(28) Burlington and May: Handbook of Probability and Statistics With Tables, Handbook Publishers, Inc., Sandusky, Ohio, 1958 printing

(29) G. Marsaglia and T.A. Bray: One-Line Random Number Generators and Their Use in Combinations, Boeing Scientific Research Laboratories Document D1-82-0689, March 1968

(30) W. Feller: Introduction to Probability Theory and Application, Vol. II, John Wiley & Sons, Inc., New York, 1966

(31) B. Epstein and M. Sobel: "Life Testing," J. American Statistical Association 48, 1953, pp. 486-502

Additional Sources Studied

A.H. Bowker and G.J. Lieberman: Engineering Statistics, Prentice-Hall Inc., Englewood Cliffs, N. J., 1959

J.P. Butler: "Fatigue Scatter and a Statistical Approach to Fatigue Life Prediction," Proceedings of Symposium on Fatigue of Aircraft Structures, WADC TR-59-507, August 1959

J.J. Coleman: "Reliability of Aircraft Structures in Resisting Chance Failure," Journal Operations Research Vol. 7, No. 5., October 1959, pp. 639-45

W. Feller: Introduction to Probability Theory and its Applications, Vol. I, John Wiley & Sons, Inc., 1953

T. Halperin: "Maximum Likelihood Estimation in Truncated Samples," Ann. Math. Statist. 23, 1952, pp. 226-38

M.V. Johns and G.J. Lieberman: "An Asymptotically Efficient Confidence Bound for Reliability in the Case of the Weibull Distribution," Technometrics 8, February 1966, pp. 135-75

S.C. Saunders and Z.W. Birnbaum: A Probabilistic Interpretation of Miner's Rule, Boeing Scientific Research Laboratories Document D1-82-0603, April 1967

S.C. Saunders: Some Statistical Aspects of the Determination of a Safe Life From Fatigue Data, Boeing Scientific Research Laboratories Document D1-82-0515, April 1966

S.C. Saunders, J.D. Esary, and Z.W. Birnbaum: "Multi-Component Systems and Structures and Their Reliability," Technometrics 3, February 1961

NOTE: See Appendix II for a bibliography of reference sources from which all fatigue data were collected.

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13. ABSTRACT

The application of reliability analysis methods to the estimation of probable aircraft structural fatigue performance was investigated. Use was made of order statistics to establish the means of assessing the fatigue performance reliability of a fleet or number of fatigue-exposed details. A reliability analysis plan for application to aluminum alloy structural fatigue performance was developed and compared with the current, fixed scatter-factor procedure for determining the safe life of a structural detail. Both the two-parameter Weibull distribution and the log-normal distribution with empirically defined shape parameter were utilized to make the reliability plan tractable as compared to a distribution-free approach. Maximum-likelihood estimators, including one which considers only the first two-ordered failures, were employed to examine the many variables that might influence fatigue scatter, to qualify fatigue data that represented aluminum structural scatter and to establish shape-parameter values that typified structural fatigue scatter. The sampling distributions of these estimates were required to work the problem and were calculated by means of existing theory or Monte-Carlo simulation. More than 2,000 groups of fatigue performance data were collected, analyzed, and used to demonstrate the feasibility of establishing a shape-parameter value. Based on this estimate, scatter factors have been generated to account for the penalty of limited input information, the degree of desired reliability, and the size of the exposed fleet. Using these factors, the possible effects of the reliability analysis on structural weight, payload, or range were explored for a jet-engined military tanker/transport-type airplane.

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	ROLE	WT	ROLE	WT	ROLE	WT
a. Fatigue-Life Variability						
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c. Reliability Analysis						
d. Statistical Analysis						
e. Order Statistics						
f. Estimation Theory						
g. Scatter Factor						
h. Safe Life						

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